

Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.



Central Great Plains Research Station

1999 Research Progress Report



40335 County Road GG
Akron, CO 80720
Phone: 970-345-2259
Fax: 970-345-2088

Website: www.akron.ars.usda.gov

TABLE OF CONTENTS

MISSION STATEMENT	1
CENTRAL GREAT PLAINS RESEARCH STATION STAFF	2
SUMMARY OF 1999 WEATHER	3
R.W. Shawcroft	
EVALUATION OF ALTERNATIVE CROP ROTATIONS TO WINTER WHEAT - FALLOW	12
J.G. Benjamin, D.C. Nielsen, R.A. Bowman, M.F. Vigil, R.L. Anderson	
INTEGRATING CROPPING SYSTEMS WITH LIVESTOCK SYSTEMS	13
D. Schutz ¹ , R.L. Anderson	
RESIDUE MANAGEMENT STRATEGIES WITH THE STRIPPER HEADER	14
R.L. Anderson	
CULTURAL SYSTEMS FOR WEED CONTROL IN SUMMER ANNUAL CROPS	15
R.L. Anderson, D.L. Tanaka ¹	
PREVIOUS CROP EFFECT ON WEED DENSITIES IN FIELD PEAS	16
R.L. Anderson	
ESTIMATING SOIL HYDRAULIC PROPERTIES FROM SPARSE DATA	17
J.G. Benjamin	
MANAGING SOIL COMPACTION TO ENHANCE CORN PRODUCTION AND SOIL BIOLOGICAL ACTIVITY	18
J.G. Benjamin, M.F. Vigil, D.C. Nielsen	
EVALUATING AND QUANTIFYING SOIL QUALITY AND PRODUCTIVITY FROM SELECTED SOIL PROPERTIES	19
R.A. Bowman	
SOIL ORGANIC MATTER CHANGES UNDER ALTERNATE CROPPING AND TILLAGE SYSTEMS	20
R.A. Bowman, M.F. Vigil, R.L. Anderson, D.C. Nielsen, J.G. Benjamin	

NUTRIENT, CEC, AND pH CHANGES UNDER ALTERNATE CROPPING SYSTEMS	21
R.A. Bowman, M.F. Vigil	
ORGANIC MATTER AND NUTRIENT CHANGES IN SIMULATED EROSION STUDIES	22
R.A. Bowman, M.F. Vigil	
ADSORPTION, MOVEMENT, AND TRANSFORMATIONS OF MANURE-P AND ORGANIC-P IN SOILS	23
R.A. Bowman, M.F. Vigil	
AGRICULTURE AND BUSINESS MANAGEMENT ACTIVITIES IN NORTHEAST COLORADO	24
D.A. Kaan	
ECONOMIC INJURY LEVEL OF RESISTANT AND SUSCEPTIBLE WINTER WHEAT VARIETIES TO RUSSIAN WHEAT APHIDS	25
M.D. Koch	
ECONOMIC INJURY LEVEL OF RESISTANT AND SUSCEPTIBLE FEED BARLEY VARIETIES TO THE RUSSIAN WHEAT APHIDS	26
M.D. Koch	
EVALUATING THE EFFICACY OF ADAGE AS A SEED TREATMENT FOR MANAGEMENT OF SUNFLOWER STEM WEEVIL, SUNFLOWER ROOT WEEVIL AND <i>Pelochrista womanana</i>	27
S. Pilcher, D. Kennedy, B. Filla, L. Charlet, M.D. Koch	
CONTROL OF SPOTTED SUNFLOWER STEM WEEVIL WITH PLANTING AND CULTIVATION TREATMENTS	28
S. Pilcher, D. Kennedy, M.D. Koch	
EFFECTS OF CROPPING ROTATIONS ON BENEFICIAL AND PEST INSECTS	29
M.D. Koch	
FORAGE AND SEED YIELD OF SEVERAL PEA AND SOYBEAN VARIETIES	31
D.C. Nielsen	

CROP ROTATION AND TILLAGE EFFECTS ON WATER USE AND YIELD OF ALTERNATIVE CROP ROTATIONS FOR THE CENTRAL GREAT PLAINS	32
D.C. Nielsen, R.L. Anderson, R.M. Aiken, M.F. Vigil, R.A. Bowman, J.G. Benjamin	
KENAF WATER USE AND PRODUCTION (FORAGE AND FIBER) UNDER A RANGE OF WATER AVAILABILITY	33
D.C. Nielsen	
WATER USE, YIELD AND AGRONOMIC PRODUCTION OF ALTERNATIVE CROPS UNDER AN IRRIGATION GRADIENT	34
D.C. Nielsen	
WINTER WHEAT-GRAIN-NITROGEN FROM LEGUME-GREEN-MANURE	35
M.F. Vigil, D.C. Nielsen, R.A. Bowman.	
NITROGEN MINERALIZATION FROM MANURES AND MUNICIPAL SEWAGE SLUDGE	36
M.F. Vigil, B. Jacubowski, J. Davis, B. Eghbal, R.A. Bowman	
SIXTEEN YEARS OF DRYLAND CROPPING WITHOUT SUMMER FALLOW	37
M.F. Vigil, R.A. Bowman	
NITROGEN, MICRONUTRIENT, AND ROW SPACING RESPONSE OF SUNFLOWERS IN A DRYLAND ROTATION	38
M.F. Vigil, J.G. Benjamin, J. Schepers, R.A. Bowman, D.C. Nielsen,	
SOIL CARBON AND NITROGEN CHANGES IN A LONG TERM TILLAGE STUDY	39
M.F. Vigil, R.A. Bowman, R.L. Anderson	
PUBLICATIONS	40

CENTRAL PLAINS RESOURCES MANAGEMENT RESEARCH UNIT

MISSION STATEMENT

To enhance the economic and environmental well-being of agriculture by development of integrated cropping systems and technologies for optimal utilization of soil and water resources. Emphasis is on efficient use of plant nutrients, pesticides, and water and soil conservation/preservation.

CENTRAL GREAT PLAINS RESEARCH STATION STAFF

Research Scientists

Randy Anderson
Joseph Benjamin
Rudy Bowman
David Nielsen
Merle Vigil

NRCS - Soil Quality Management Team

Manuel Rosales
Josh Saunders

Colorado State University

Mahdi Al-Kaisi
Jim Hain
Dennis Kaan
Mike Koch
Bonnie Fisher

Research Support Staff

Karen Couch
Albert Figueroa
Robert Florian
Donna Fritzler
Linda Hardesty
Michele Harms
Stephanie Hill
Eric Keane
Delbert Koch
Marrietta Koch
Gene Uhler
Lori Ziehr

Administrative Support Staff

Ginger Allen
Carolyn Brandon
Linda Pieper
Lewellyn Bass

SUMMARY OF 1999 WEATHER

CENTRAL GREAT PLAINS RESEARCH STATION AKRON, COLORADO

R. Wayne Shawcroft

Regional Extension Irrigation Agronomist-(Retired)

Farm Service Representative, Citizens National Bank of Akron

While “El Niño” appeared to be the dominating factor for the 1998 weather, El Niño’s sister phenomena, La Niña, was all the rage for 1999. These two features have dominated the global weather discussion for nearly three years. The surprising result for Eastern Colorado is that each of these features causes the same thing, namely alternating periods of very warm and very dry conditions, with wet and warm conditions. It appears that both conditions have led to the warm winters that have prevailed.

The most significant feature of the 1999 calendar weather was the very warm winter conditions. This is a continuing feature spread over two different winter seasons. Near record breaking warmth began in September 1998, continued through Dec. 1998, and well into January through March of 1999. April of 1999 was the first month since Sep. ’98, that the mean temperature was below the long-term average.

In addition to the mild temperatures, the other feature was the heavy late summer period rainfall. Seventy-nine percent of the total annual precipitation for 1999 came during the May 1 through Sept. 30 period. The total rainfall for the month of August, 6.45 inches, was the highest total for any month since July of 1946.

TEMPERATURES

Monthly mean, maximum, and minimum temperatures are shown in Tables 1, 2, and 3 (also see graph of Monthly Mean Temp:). The January, February, and March temperatures (mean, maximum, and minimum) were all considerably above the average. While no new average records were set, the January mean for 1999 was the 4th warmest on record, at 8.3 degrees above the average. Similarly, the average maximum was the 9th warmest, and the average minimum the 4th warmest. For February, the average mean was nearly 8.5 degrees warmer than the long-term average and ranked as the 2nd warmest February. The average maximum for February was a whopping 12 degrees above average, the 3rd warmest; and the average minimum for February was over 5 degrees above the average. This same pattern prevailed through March, although tempered somewhat. April, was cooler and wetter, and the first month since Sep. 1998 with a mean temperature cooler than the long-term average.

The summer months cooled somewhat. May, June, and August were just average or cooler, while July was just slightly warmer than average. As rain and humidity increased in August, the result was slightly below average maximums and slightly above average minimums. September was the only month of the year that was substantially cooler than average. While 90 plus maximums are common in early September, the daily maximums were predominately in the 70’s and 80’s, with only one 90 degree maximum in the month. A cold, snowy period occurred in

late September. The first 32 deg F temperature occurred on the 13th, while the first "killing" frost was about on schedule with a 28 degree low on the 28th.

After a relatively mild and average October, the winter time warmth returned in November and December. The November mean was 7.8 degrees above average, ranking as the 2nd warmest November. The November average maximum was over 11 degrees above the average, again ranking as the 2nd highest on record. There were 10 new daily high temperature records (6 maximums and 4 means) set in November. The trend continued into December with the average maximum, minimum, and mean running about 5 degrees above the long-term average.

What does this mean for the entire year? (See the "Annual Mean Temp." graph). The average annual mean temperature (average of the daily mean for the 365 days) was 51.08 degrees which ranks **1999** as the **3rd warmest year** on record. Only 1934 at 52.64 degrees and 1963 at 51.37 were warmer. With regard to "warming" trends, the warmest 10% of the years have three years in the 1930's, two in the '50's and 60's, two in the 1980's, and two in the 1990's. To say that the 90's have a definite warming trend is not readily apparent. Of the last 10 years four have been above average, six have been below average, including the 3rd coldest year on record, 1993.

There were **no "below zero" temperatures** in the calendar year 1999. The coldest temperatures reached were a 2 degree minimum on Feb. 12 and a 1 degree minimum on Dec. 20. Warmer winter minimums are probably the most significant of any trend detectable.

A summary of the **Growing-Degree-Days (GDD)** for the summer months is shown in Table 4. The final **GDD** total was slightly below the average of 2510 units. The graph of the **GDD** accumulation shows that 1999 followed almost exactly as the average. Table 4. also shows that there were considerably fewer 90+ days, about one less 100+ day than average, and about nine more days with a minimum of 55 degrees or less, for the summer of 1999. Most crops matured in normal fashion, and early frost was not a factor.

PRECIPITATION

The **annual total precipitation for 1999** was **20.57 inches**, which ranks as the **15th wettest** or **78th driest** of the 92-year record, and one of only 17 years out of 92 with totals greater than 20 inches. The May 1 - Sept. 30 period total was 16.34 inches or 79% of the total annual. Most significant was the **6.45 inch total for August**, which ranks this August as the second wettest August on record. This monthly total was the wettest monthly total since July of 1946. Again the winter months, Jan., Feb., and March were below average. October and November again below average.

Hail again was a factor, with severe storms at the end of May, and several in the latter part of August.

Snowfall was very low, and corresponds with the extremely warm conditions. Calendar year totals were about evenly split with 10.5 inches in the Jan. - April period, and 11.5 inches in the Sep. - Dec. period. The biggest snowfall of the calendar year was the Nov. 22-23 storm of about 5 inches.

The following tables and graphs show other features of the 1999 weather year, and compare the 1999 season with the long-term record. This completes the 92nd year of compilation of daily rainfall and temperature records at the Research Station. Congratulations to Bob Florian, for receiving an award for 45 years as a Cooperative Weather Observer.

TABLE 1. AVERAGE MONTHLY MEAN TEMPERATURES
(Based on 8:00 am daily observation time)

1999 TEMPERATURES

USDA-ARS RESEARCH STATION, AKRON, CO

MEAN TEMPS		92-YEAR						
MONTH	1999 AVERAGE	1908-99 AVERAGE	DEPARTURE	HIGH AVERAGE	(YEAR)	LOW AVERAGE	(YEAR)	
JAN	33.42 °F	25.24 °F	8.18 °F	35.4	(1986)	7.8	(1937)	
FEB	38.46	29.98	8.48	41.1	(1954)	16.0	(1929)	
MAR	41.58	36.40	5.18	45.5	(1986)	19.9	(1912)	
APR	44.37	46.42	-2.05	53.6	(1930)	35.9	(1920)	
MAY	56.10	56.21	-0.12	65.3	(1934)	48.0	(1995)	
JUN	65.72	66.54	-0.82	73.5	(1956)	59.1	(1945)	
JUL	75.16	73.31	1.85	79.9	(1934)	67.6	(1915)	
AUG	71.37	71.45	-0.08	77.0	(1983)	65.3	(1927)	
SEP	59.03	62.32	-3.28	68.4	(1998)	53.8	(1965)	
OCT	50.47	50.33	0.14	59.0	(1963)	40.7	(1969)	
NOV	44.53	36.73	7.80	45.8	(1949)	23.5	(1929)	
DEC	32.74	27.59	5.15	36.3	(1980)	12.7	(1983)	
YEARLY AVE								
MEAN TEMP	51.079 °F	48.5432 °F	2.536 °F	52.64	(1934)	44.81	(1912)	

ALL TEMPERATURES IN DEGREES F 1999 DATA INCLUDED IN AVERAGES

MAX TEMPS

TABLE 2. AVERAGE MONTHLY MAXIMUM TEMPERATURES

JAN	46.52 °F	37.95 °F	8.56 °F	49.6	(1934)	20.8	(1937)
FEB	54.64	42.76	11.88	56.0	(1954)	28.6	(1929)
MAR	57.81	49.70	8.11	60.6	(1972)	28.7	(1912)
APR	57.33	60.44	-3.11	69.9	(1908)	45.7	(1920)
MAY	70.16	69.99	0.17	81.9	(1934)	57.5	(1995)
JUN	80.37	81.27	-0.91	89.6	(1952)	70.0	(1928)
JUL	90.39	88.72	1.67	97.6	(1934)	81.2	(1915)
AUG	85.19	86.80	-1.60	93.8	(1937)	77.5	(1927)
SEP	73.90	77.95	-4.05	85.8	(1998)	65.6	(1965)
OCT	67.45	65.81	1.64	75.1	(1963)	50.8	(1969)
NOV	61.53	50.44	11.09	62.2	(1949)	33.0	(1929)
DEC	45.19	40.16	5.04	51.6	(1957)	22.4	(1983)
YEARLY AVE							
MAX TEMP	65.874 °F	62.666 °F	3.208 °F				

MIN TEMPS

TABLE 3. AVERAGE MONTHLY MINIMUM TEMPERATURES

JAN	20.32 °F	12.52 °F	7.81 °F	22.9	(1953)	-5.3	(1937)
FEB	22.29	17.19	5.10	26.6	(1992)	2.2	(1936)
MAR	25.35	23.11	2.25	30.9	(1986)	11.0	(1912)
APR	31.40	32.39	-0.99	39.3	(1930)	26.1	(1920)
MAY	42.03	42.44	-0.40	48.6	(1934)	36.5	(1917)
JUN	51.07	51.80	-0.73	57.7	(1956)	46.0	(1945)
JUL	59.94	57.90	2.03	62.6	(1966)	54.1	(1915)
AUG	57.55	56.11	1.44	60.8	(1983)	52.2	(20&74)
SEP	44.17	46.69	-2.52	52.6	(1963)	41.2	(12&45)
OCT	33.48	34.85	-1.37	43.0	(1963)	28.9	(1917)
NOV	27.53	23.02	4.52	29.4	(1998)	14.0	(1929)
DEC	20.29	15.03	5.26	21.9	(1946)	3.1	(1983)
YEARLY AVE							
MIN TEMP	36.285 °F	34.420 °F	1.865 °F				

saved as: TEMP99a printed: 1/8/00

TABLE 4. SUMMER GROWING SEASON RAINFALL, TEMPERATURE, AND GROWING DEGREE-DAY SUMMARY
FOR USDA-ARS RESEARCH STATION, AKRON, COLORADO [1999 & 92-AVERAGE]

RAINFALL inches			TEMPERATURE DATA									
			AVERAGE		GROWING		NUMBER OF DAYS 90 or ABOVE; 100 or Above; 55 or BELOW					
			MEAN TEMP Deg F		DEGREE-DAYS**		AKRON -- 1999			AKRON 92-YR AVE		
MONTH	1999*	AVG*	1999*	AVG*	1999*	AVG*	90+	100+	<55	90+	100+	<55
MAY	2.16	3.00	56.10	56.21	231.5	235.2	0	0	31	0.9	0.0	30.4
JUN	3.44	2.49	65.72	66.54	471.5	499.4	6	0	24	7.5	0.6	21.8
JUL	2.70	2.70	75.16	73.31	780.0	722.8	19	2	4	16.0	2.0	8.8
AUG	6.45	2.10	71.37	71.45	662.5	665.2	10	0	5	13.4	0.8	13.1
SEP	1.59	1.23	59.03	62.32	309.5	387.9	1	0	27	4.8	0.1	26.5
TOTALS	16.34	11.52	65.52	65.97	2455.0	2510.4	36	2	91	42.7	3.5	100.7

* 92-year average rainfall and temperature data(1908-1999); and number of days 90 or above, 100 or above, and 55 or less, at Central Great Plains Res. Sta., Akron, Colorado

** GROWING DEG-DAYS defined as number of days with daily mean temperature above a 50-degree F base. For example: Max = 85; Min = 53; Mean = (85+53)/2=69. Deg-Day unit = 69 - 50 = 19 GDD units.

AKRON GDD UNITS ACCUMULATED FROM MAY 1 THROUGH SEPT. 30.

TBL41999.XLS 01/12/2000

TABLE 5. RAINFALL AMOUNTS BY MONTHS. USDA-ARS, AKRON, COLORADO

1999 RAINFALL SUMMARY

(Based on 8:00 am daily observation time)

MONTH	1999 TOTAL	92-YEAR AVE AVE. 1908-99	DEPART.	% OF AVERAGE	HIGH TOTAL (YEAR TOTAL (YEAR)	LOW TOTAL (YEAR TOTAL (YEAR)	1999 CUM	91-YR AV CUM	DEPART. CUM	% OF AVERAGE	MON
JAN	0.07 inches	0.33 inches	-0.26	21.1%	1.51 (1988)	0.00 (6 YRS)	0.07	0.33	-0.26	21.1%	JAN
FEB	0.15	0.35	-0.20	43.3%	1.68 (1915)	0.00 (9 YRS)	0.22	0.68	-0.46	32.4%	FEB
MAR	0.28	0.82	-0.54	34.2%	3.06 (1909)	0.00 (1908)	0.50	1.50	-1.00	33.4%	MAR
APR	2.26	1.66	0.60	136.2%	5.19 (1915)	0.17 (1928)	2.76	3.16	-0.40	87.5%	APR
MAY	2.16	3.00	-0.84	72.1%	7.79 (1917)	0.13 (1974)	4.92	6.15	-1.23	80.0%	MAY
JUN	3.44	2.49	0.95	138.0%	6.11 (1965)	0.19 (1952)	8.36	8.64	-0.28	96.7%	JUN
JUL	2.70	2.70	0.00	100.1%	7.22 (1946)	0.31 (1934)	11.06	11.34	-0.28	97.5%	JUL
AUG	6.45 **	2.10	4.35	306.9%	7.36 (1918)	0.16 (1973)	17.51	13.44	4.07	130.2%	AUG
SEP	1.59	1.23	0.36	128.8%	4.83 (1950)	0.00 (1978)	19.10	14.68	4.42	130.1%	SEP
OCT	0.45	0.90	-0.45	49.8%	3.71 (1993)	0.00 (3 YRS)	19.55	15.58	3.97	125.5%	OCT
NOV	0.47	0.56	-0.09	84.5%	2.67 (1946)	0.00 (3 YRS)	20.02	16.14	3.88	124.0%	NOV
DEC	0.55	0.41	0.14	133.2%	3.27 (1913)	0.00 (1908,28)	20.57	16.55	4.02	124.3%	DEC
Total	20.57 inches	16.5522 inches	4.02	124.3%	26.79 (1946)	9.93 (1939,74)	20.57	16.55	4.02	124.3%	

LAST UPDATE>> 08-Jan-2000
1999 DATE INCLUDED IN AVERAGE

** wettest month since July 1946

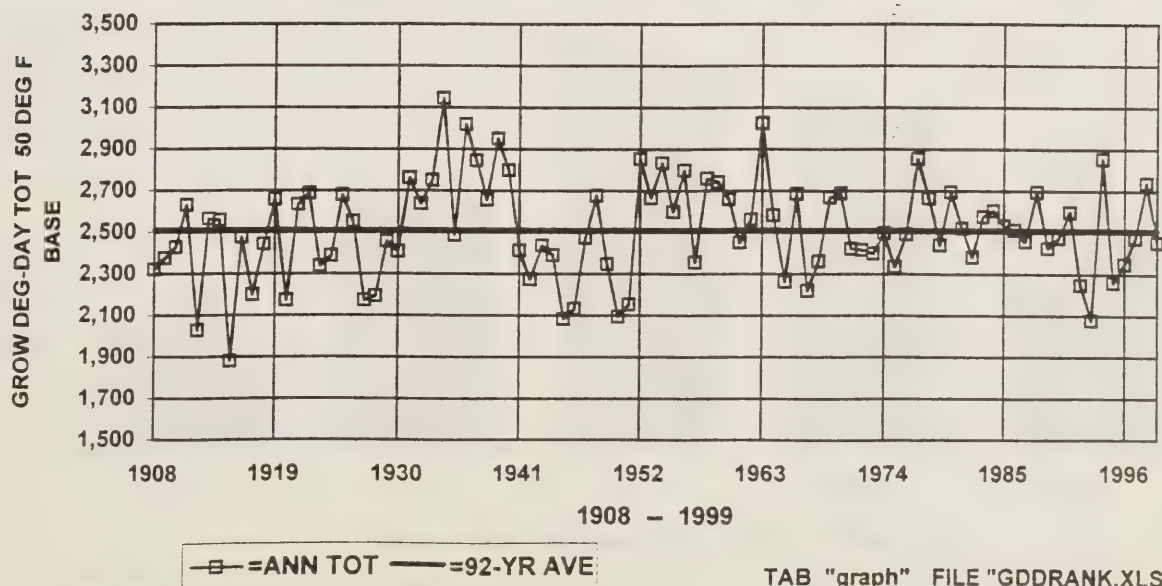
Saved as: 99RAINCUL.XLS printed on: 01/12/2000

Table 6. Snowfall Dates and Depths for Calendar Year 1999
USDA-ARS Research Station, Akron, Colorado

DATE	Snow Depth inches	Precipitation inches
Jan 1-4	2.00	0.07
Jan 14	Trace	Trace
Jan 22	Trace	Trace
Feb 15	1.50	0.15
Feb 22	Trace	Trace
Mar 1-2	Trace	Trace
Mar 6	Trace	Trace
Mar 8-9	0.50	0.07
Mar 12-13	2.00	0.18
Apr 3	0.50	0.05
Apr 5-6	3.00	0.37
Apr 23	1.00	0.32
Sub-Total	10.50	1.21
Sep 28-29	4.00	1.18
Nov 22-23	5.50	0.47
Dec 4	Trace	0.07
Dec 20	2.00	0.10
Dec 22-23	Trace	Trace
Sub-Total	11.50	1.82
TOTALS	22.00	3.03

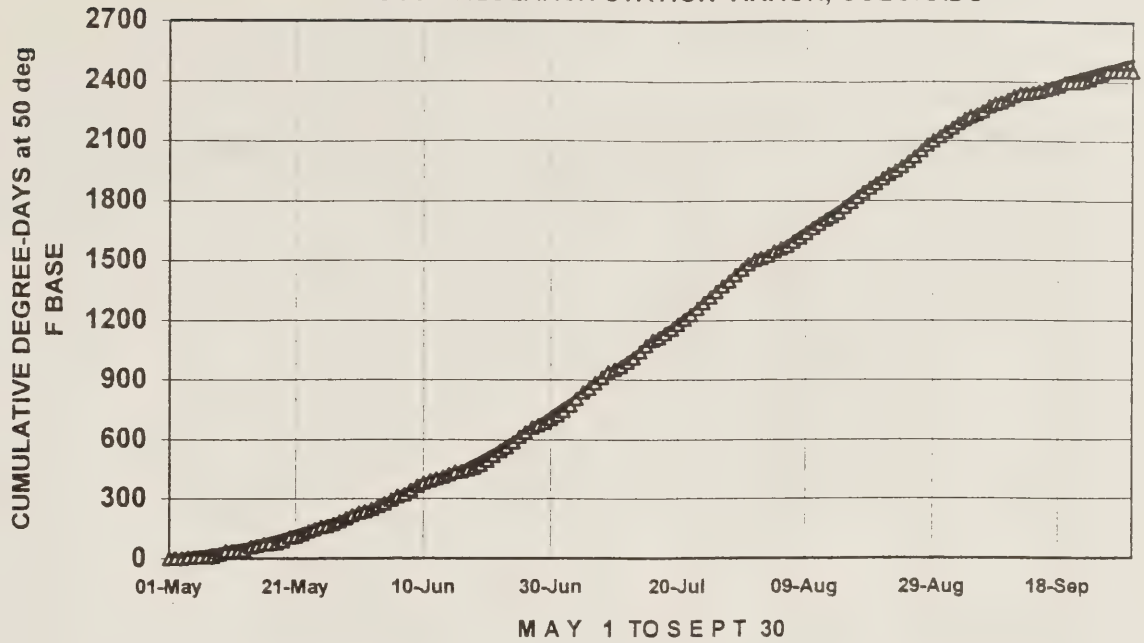
SNOW99.XLS 01/12/2000

GROWING DEGREE-DAYS (MAY-SEPT)
USDA-ARS RESEARCH STATION, AKRON, CO



TAB "graph" FILE "GDDRANK.XLS"
printed: 01/12/2000

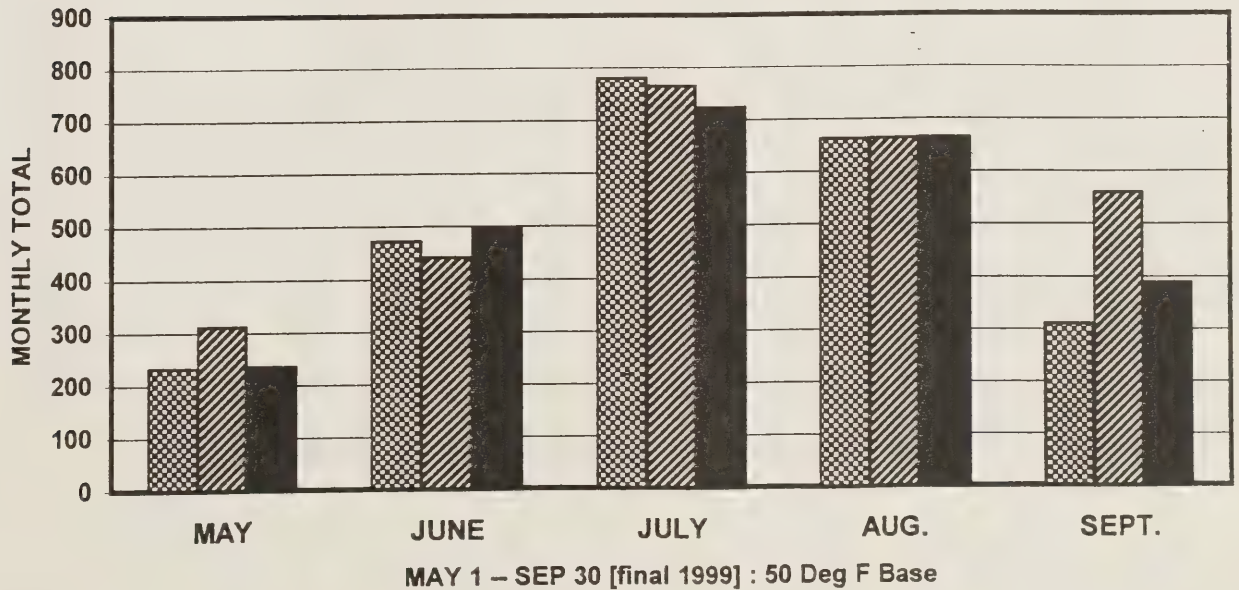
GROWING DEG-DAYS: 1999 & 92-YR AVE
USDA RESEARCH STATION AKRON, COLORADO



GDD99.XLS PRINTED: 01/11/2000

Δ =1999 — =92-YR AVE.

MONTHLY DEG-DAY TOTALS: 1999,1998 & 92-yr Ave
USDA-ARS RESEARCH STATION, AKRON, CO



▨ 1999 ▤ 1998 ■ 92-yr av

GDDSMY99.XLS printed: 01/11/2000

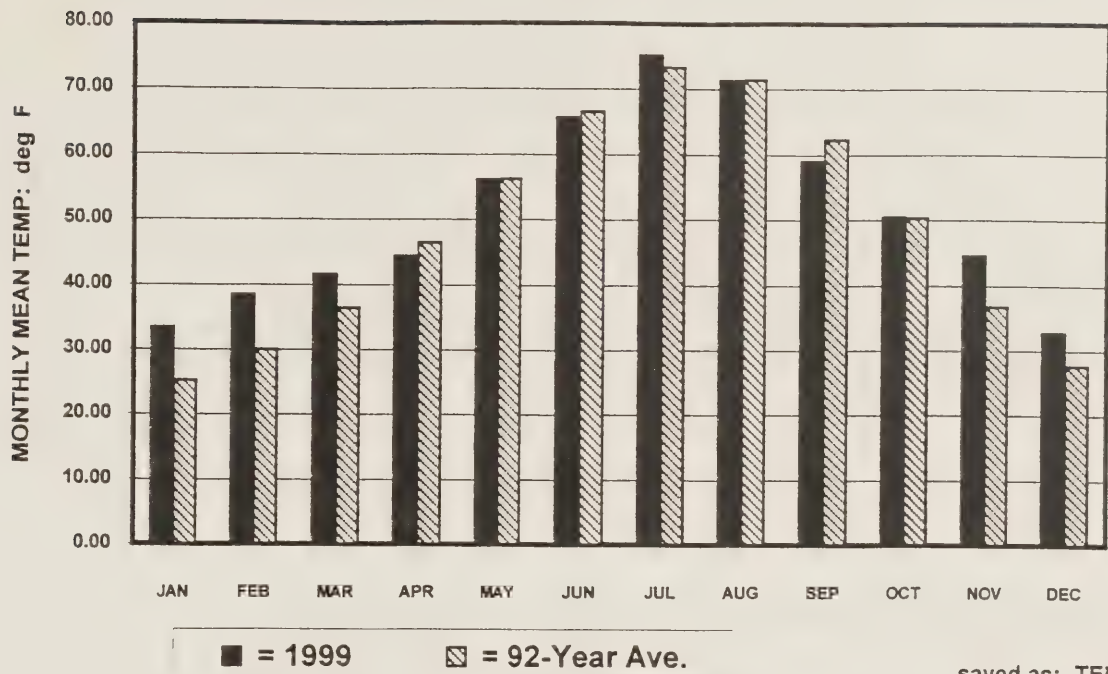
1999 RAINFALL													
CENTRAL GREAT PLAINS RESEARCH STATION AKRON, COLORADO PRECIPITATION LOG 1998 STANDARD GUAGE inches LOCATION: WEATHER STATION [Rainfall amounts are for the period 12:00 midnight to 12:00 midnight for the date recorded.]													
DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1	0.05				0.41		0.02	0.27					1
2	0.01		T	0.03									2
3	0.01		T	0.02								0.05	3
4								0.25				0.02	4
5			T	0.37				1.71					5
6								1.09					6
7										0.33			7
8			0.07	0.10									8
9													9
10		0.09				1.46							10
11		0.06				0.08	0.18						11
12			0.15				T						12
13	T		0.03										13
14				0.07	0.28	0.23	T						14
15													15
16				T	0.22		1.35						16
17					0.05	0.04		0.08		0.12		0.38	17
18							0.02			T			18
19	T				0.02		0.02		0.28			0.10	19
20						0.15	0.03		0.13				20
21				0.20				1.22			0.11		21
22	T	T	T	0.15							0.30		22
23				0.23							0.06		23
24				0.03									24
25				0.69					T				25
26				0.16			0.32		1.18				26
27			0.03		0.10								27
28				0.05		0.49		1.53					28
29				0.15	0.69			0.20					29
30				0.40		0.19	0.57						30
31	T				0.99		0.10						31
SUM	0.07	0.15	0.28	2.65	2.76	2.64	2.61	6.35	1.59	0.45	0.47	0.55	MONTHLY TOTAL
AVE	0.33	0.35	0.82	1.66	3.00	2.48	2.70	2.10	1.23	0.90	0.56	0.41	92 Year Ave
DEP	-0.26	-0.20	-0.54	0.99	-0.24	0.16	-0.09	4.25	0.36	-0.45	-0.09	0.14	DEPARTURE
%NORM	21.1%	43.3%	34.2%	159.3%	91.9%	106.3%	96.8%	302.3%	128.8%	49.8%	84.5%	133.2%	MONTHLY % OF NORMAL
CUM	0.07	0.22	0.50	3.15	5.91	8.55	11.16	17.51	19.10	19.55	20.02	20.57	CURRENT ACUM
AVCM	0.33	0.68	1.50	3.16	6.16	8.65	11.34	13.44	14.68	15.58	16.14	16.55	AVE ACUM
DEP	-0.26	-0.46	-1.00	-0.01	-0.25	-0.10	-0.18	4.07	4.42	3.97	3.88	4.02	DEPARTURE
%of NORM	21.1%	32.4%	33.4%	99.7%	95.9%	98.9%	98.4%	130.2%	130.1%	125.5%	124.0%	124.3%	CUM % OF NORM

LAST UPDATE>>> 08-Jan-00

NOTE: NEW MONTHLY AVERAGE IS CALCULATED.....NEW AVERAGE INCLUDES 1999 RAINFALL DATA

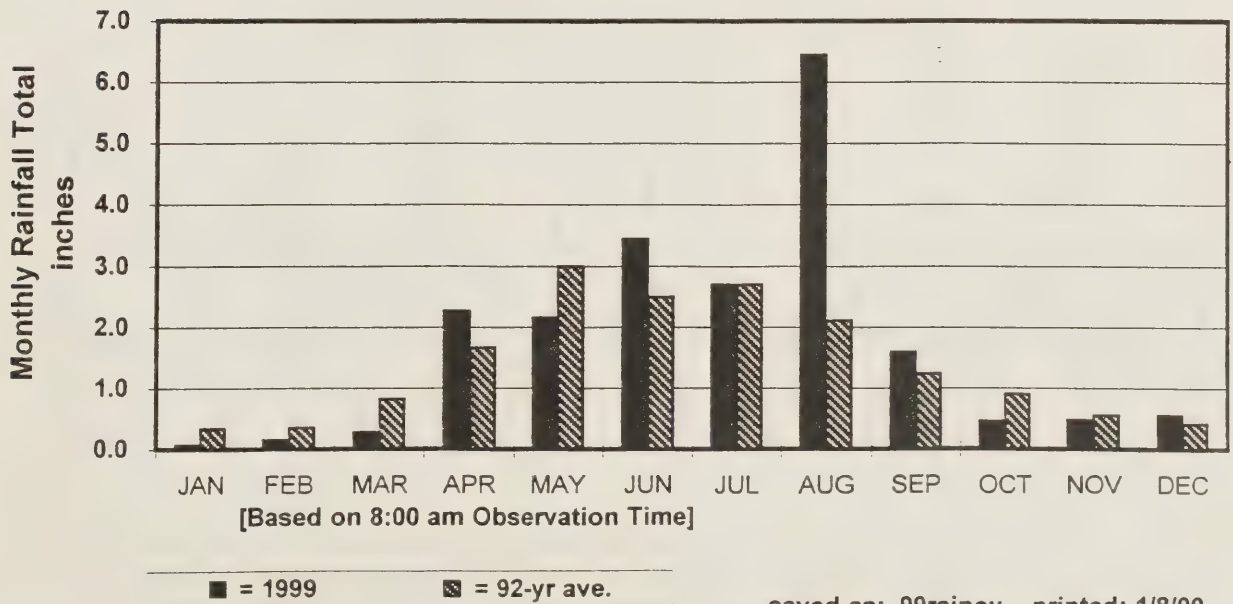
Rain99w 1/8/00

MONTHLY MEAN TEMP: 1999 & 92-YEAR AVE
USDA-ARS AKRON, COLORADO



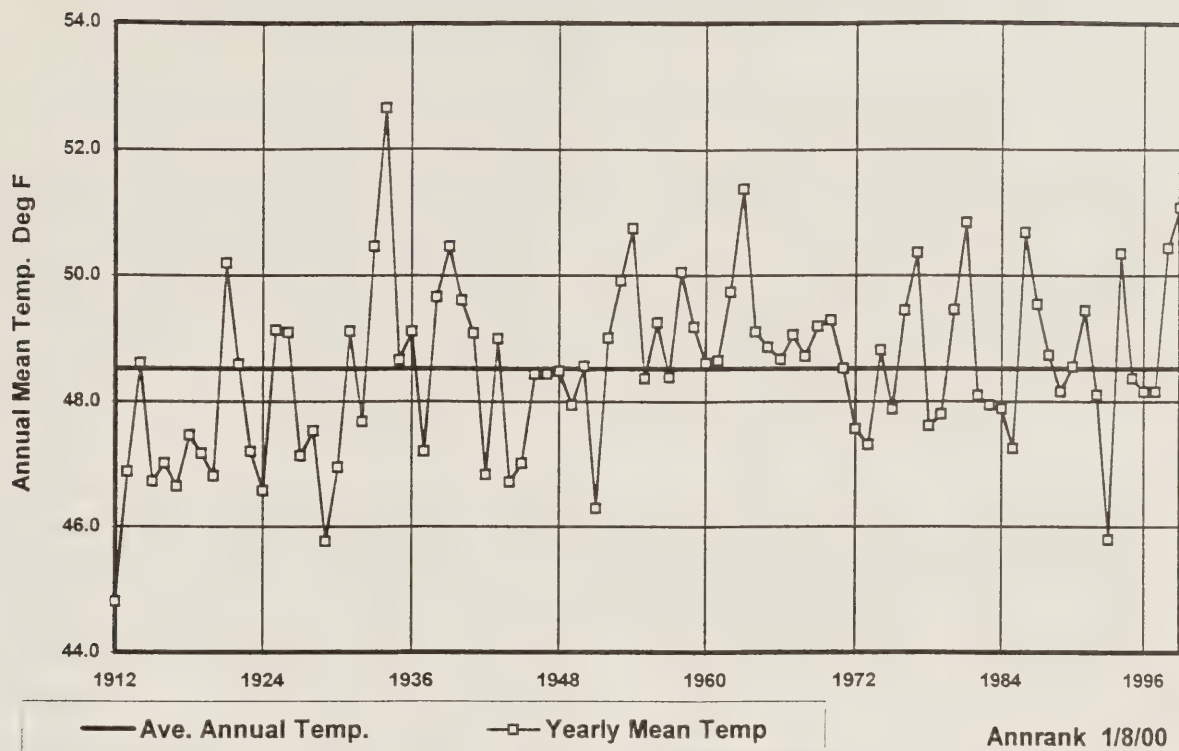
saved as: TEMP99a

MONTHLY RAINFALL TOTAL 1999 & 92-Yr Ave inches
USDA-ARS RESEARCH STATION Akron, Colorado

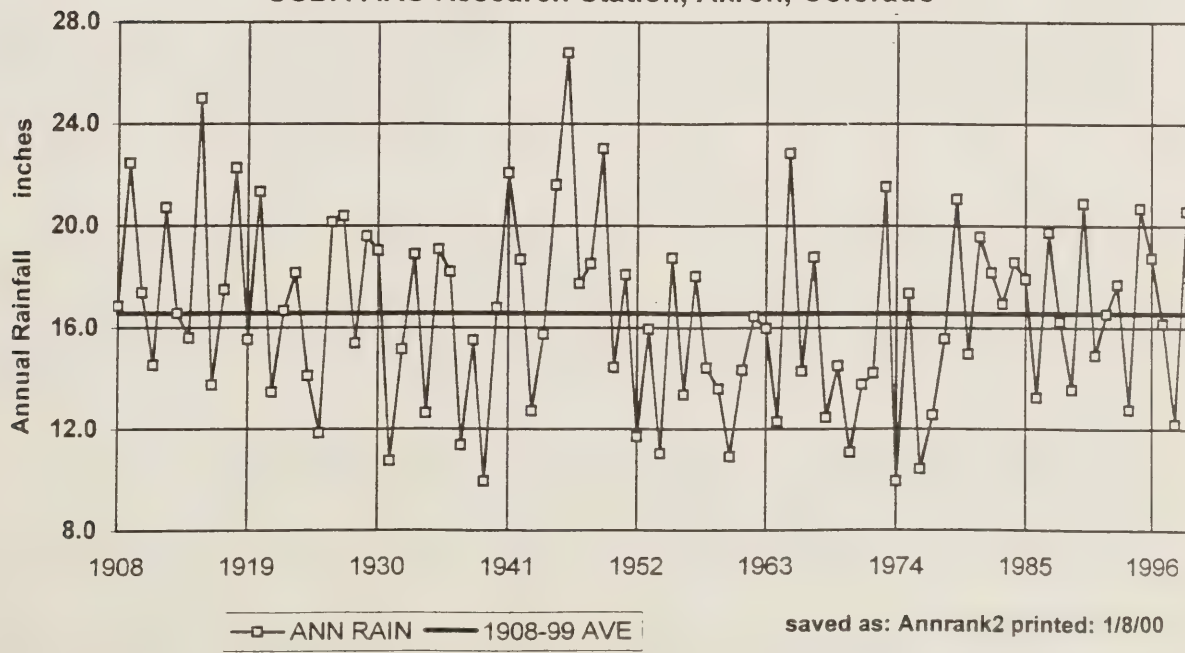


saved as: 99raincu printed: 1/8/00

ANNUAL MEAN TEMP. Deg F
USDA-ARS Research Station, Akron, Colorado



ANNUAL TOTAL RAINFALL 1908-1999
USDA-ARS Research Station, Akron, Colorado



EVALUATION OF ALTERNATIVE CROP ROTATIONS TO WINTER WHEAT - FALLOW

J.G. Benjamin, D.C. Nielsen, R.A. Bowman, M.F. Vigil, R.L. Anderson

PROBLEM: Producers in the Central Great Plains rotate winter wheat with fallow; fallow enables producers to stabilize wheat production. However, fallow degrades soil by increasing loss of organic matter and organic nitrogen while exposing soil to wind and water erosion. Producers can counter this trend in soil degradation by cropping more frequently. Improved weed control methods during non-crop periods have increased precipitation storage efficiency such that more soil water is available for crop growth. Also, new crop varieties are more efficient in converting water into grain, thus the need for fallow may be less than historically perceived. This study is evaluating crop rotations to increase cropping intensity and subsequently, reduce the amount of fallow.

APPROACH: A crop rotation study with 16 rotations was initiated in 1990 on a Weld silt loam at the Central Great Plains Research Station. Crops include: winter wheat, corn, sunflower, proso millet, foxtail millet, field pea, and triticales. With all rotations, we are minimizing tillage. Tillage is required to incorporate herbicides for sunflower. Three tillage systems, conventional-reduced-, and no-till, are included in the wheat-fallow rotation as a basis for comparing soil quality changes. Standard agronomic practices for seeding rates, planting dates, varieties, and weed control are being followed.

RESULTS: Precipitation was favorable for crop growth in 1999. Wheat yields in W-F (RT) were 58 bu/ac. We have observed that wheat responds more to reduced- and no-till systems during wet years. The rotation effect of crop diversity is prominent with wheat yields; however, the trend is the opposite of the no-till effect; wheat yields are improved by rotations more in the dry years. For example, in 1999, with favorable precipitation, wheat yield was not affected by rotation. In contrast, in 1998, a drought year, the rotation effect improved wheat yields 34% [comparing wheat yields in W-C-M-F to W-F (RT)]. Sunflower in the rotation can affect wheat yields, especially in dry years. Wheat yields were not reduced if sunflower was included in a 4-year rotation (W-C-S-F). However, wheat yield in W-S-F was reduced 50%, compared to W-C-S-F.

With the favorable precipitation and high wheat residue levels, corn yielded 80+ bu/ac, with highest yields in W-C-F and W-C-M-F. In continuous cropping, corn yields ranged between 38 and 66 bu/ac. Low wheat residues in continuous cropping may have reduced corn yields. It appears that corn is synergistic to proso, as proso yields are highest when corn is the preceding crop. This trend is more prominent in wet years. Sunflower yielded the most when grown in 4-year rotations. Sunflower in W-S-F yielded 20% less than sunflower in W-C-S-F.

We are now recognizing some unique trends in yields, such as corn synergism to other crops, the interaction between precipitation levels and the rotation effect, and wheat's response to minimum-till systems. We are evaluating W-W-C-M and W-C-M-Pea to test if the rotation effect can be enhanced by including a low-water-using broadleaf crop such as pea.

FUTURE PLANS: We are cooperating with a soil microbiologist (Lynne Carpenter-Boggs, Morris, MN), to increase our understanding of microbial changes due to rotations.

INTEGRATING CROPPING SYSTEMS WITH LIVESTOCK SYSTEMS

D. Schutz¹, R.L. Anderson

PROBLEM: The Central Great Plains Research Station is exploring alternative crop rotations, with the goal of increasing cropping intensity and crop diversity. The CSU Eastern Colorado Research Center (ECRC) at Akron is exploring alternative feed sources for effect on weight gain and overwintering of livestock. Inclusion of livestock in the overall production system not only increases potential use and markets for alternative crops, but also serves as drought insurance (poor grain crops can be turned into forage). The purpose of this team effort is to implement alternative cropping systems at ECRC for better utilization of crop aftermath and alternative forages while reducing annual cow costs.

APPROACH: An integrated crop-livestock study was initiated in the fall of 1998 at the ECRC. Three cropping systems are being compared: 1) W-C-Proso-Spring Pea (as green fallow); 2) W-C-Proso-Spring Pea (for grazing); and 3) Triticales-W-C-Foxtail Millet-Spring Pea-Foxtail Millet. The cropping aspect of this study will supplement the Alternative Crop Rotations Study at the ARS station, as the soil type at the ECRC is an Ascalon sandy loam, contrasting with the Weld silt loam at the ARS site.

With systems 2 and 3, grazing will be integrated with selected crops. Corn stalks will be grazed during winter; foxtail millet will be swathed, with the swaths grazed in the fall; peas will be grazed in early summer; and triticales will be grazed either in the fall or spring, or harvested for hay, depending on range conditions as affected by seasonal precipitation.

Breeding will be managed for calving to occur in late April, which coincides with available forage with either triticales or peas. Peas also can be grazed in early summer by calves after weaning. Livestock will be the cow-calf herd maintained on the ECRC station, and weight gain and condition score will be measured.

RESULTS: Grazing triticales and winter wheat in the winter was not detrimental to grain yields. This yield trend may reflect the favorable precipitation received during May and June. Cattle performance on winter crops was superior to hay-fed cattle.

Grazing windrowed foxtail millet has been effective, with feed quality and cattle gain similar to baled hay. The advantage of windrowed foxtail millet is reduced cattle feeding costs. Cattle apparently do not like Austrian winter peas in the field, as they grazed weeds before they would feed on pea forage. A field day for producers was held on October 1, 1999, where producers expressed strong interest in the systems approach, both in reducing input costs and improving soil quality.

FUTURE PLANS: Our long-term objective is to develop integrated production systems for diversified farms, where intensive cropping is combined with alternative cattle feeding programs. We will replace Austrian winter peas with spring peas.

¹Eastern Colorado Range Station, Akron.

RESIDUE MANAGEMENT STRATEGIES WITH THE STRIPPER HEADER

R.L. Anderson

PROBLEM: Results from our alternative cropping systems study are suggesting various principles related to semiarid production systems. Continuous cropping improves soil health considerably, thus improving crop performance, especially in dry years. Planning a rotation with a cycle of four crops accrues multiple benefits such as reduced weed populations and increased grain yield. A key component of this new semiarid system is maintaining crop residue on the soil surface.

However, when wheat is grown in systems without a fallow period, both grain and residue production are extremely low, especially in dry years. The low crop residue levels usually reduce growth of following crops such as corn or proso millet. The stripper header leaves more crop residue standing upright, which may lengthen persistence of residue after harvest. Our objective with this study is to determine if harvesting wheat with a stripper header could compensate for low residue quantities produced by wheat in more intensive rotations.

APPROACH: Plots are located in a field with a cropping history of wheat-wheat-corn-millet.

Year 1: Four treatments, fallow (NT), pea as green fallow, pea for forage, and wheat, have been established in proso millet stubble.

Year 2: Next fall (2000), winter wheat will be planted into each plot. After harvest, plots will be split into two subplots; one subplot will be harvested with a standard header, and the second subplot will be harvested with the stripper header. Residue quantities will be measured after wheat harvest and before corn planting.

Year 3: Corn will be planted into each plot in 2001. Weed seedling emergence will be recorded weekly in each plot. Foxtail millet and soybean will be planted in each plot. Plant growth will be measured periodically to determine residue impact on weed fitness. Corn grain yields will be measured.

A second set of plots will be initiated in proso stubble in the fall of 2000.

RESULTS: Study was established in the fall of 1999.

FUTURE PLANS: Our goal is to integrate this strategy with crop sequencing in a four-year cycle, thus devising crop rotations that favor winter wheat growth, minimize weed densities in corn, and support continuous cropping to improve soil health. We are continuing our focus on strengthening the natural competitiveness of crops to weeds.

CULTURAL SYSTEMS FOR WEED CONTROL IN SUMMER ANNUAL CROPS

R.L. Anderson, D.L. Tanaka¹

PROBLEM: Producers are seeking production practices that reduce pesticide use for economic and environmental reasons. Cultural practices, such as narrow rows and increased plant populations, may enable producers to enhance crop competitiveness to weeds. For example, by reducing row spacing from 76 to 38 cm and doubling the planting population of corn, producers can reduce herbicide use in the Eastern U.S. by 75% without reducing weed control. These cultural practices also may work with summer annual crops in the Central Great Plains.

Research with cultural practices usually focuses on the effect of one or two practices on weed control, but does not evaluate systems based on several cultural practices in combination. This study is examining the impact of cultural practice systems on weed growth and interference in corn and sunflower. The ultimate goal is to develop a cultural system that eliminates need for herbicides or if herbicides are needed, favors reduced rates of herbicides.

APPROACH: Sunflower. We are comparing cultural systems comprised of row spacing (15 versus 30-inch), planting population (16,000 vs 20,000), and delayed planting (early June vs 10-day delay). Weed biomass is measured when sunflower begins to flower. Seed yield and oil content are measured at harvest. Each plot is split into weed-free and weed-infested sub-plots. Weed-free subplots have Spartan applied for in-crop weed control, and escaped weeds are pulled by hand.

Corn. Cultural systems comprised of N fertilizer placement (banding vs broadcast), planting population (15,000 vs 19,000), and row spacing (15 vs 30-inch) were evaluated for impact on weed growth and grain yield. Each plot was split in two, with one half maintained weed-free by herbicides and hand weeding. Foxtail millet was planted in the weed-infested subplots, as an indicator species to measure impact of cultural systems on weed growth. Weed biomass was harvested when corn began tasseling. Grain yield was determined for both weed treatments.

RESULTS: Sunflower. Cultural systems reduced weed biomass by 85%. A key component of this system is delayed planting. Above normal precipitation in August resulted in higher yields in the later plantings. Highest yields occurred in the cultural system of narrow rows at later plantings. Yield loss in the weed-infested conventional system was 30%; yield in the cultural system with narrow rows, 20,000 plants/acre, and delayed planting was not affected by weed interference.

Corn. We have tested cultural systems in corn for 3 years. Growing season precipitation varied from 70% to 130% of normal, yet cultural systems favored corn over weeds similarly in all years. The cultural system comprised of N banding, 15-inch row spacing, and 19,000 plants/acre, reduced weed biomass 60% and increased corn tolerance to weeds 3-fold. Grain yield loss was only 13% in the cultural system, contrasting with 43% yield loss due to weeds in the conventional system (N broadcast, 15,000 plants/acre, and 30-inch rows).

FUTURE PLANS: We plan to finish the cultural systems study in sunflower in 2000.

¹USDA-ARS, Mandan ND.

PREVIOUS CROP EFFECT ON WEED DENSITIES IN FIELD PEAS

R.L. Anderson

PROBLEM: Our rotation study suggests that a 4-yr rotation with two winter crops followed by two summer crops may be the most favorable for producers to maximize the rotation effect and control weeds. The predominant crops grown in the Central Great Plains regions are grasses. Broadleaf crops have been shown to improve yields of following grass crops; this effect is attributed to the diversity of crops in rotation.

One possible broadleaf crop for this region is field peas. However, yield and economic returns with peas have been low, thus input costs need to be minimized. The objective of this study is to quantify the effect of previous crop on weed densities in peas. Our ultimate goal is to develop a production system for peas that eliminates the need for herbicides.

APPROACH: Wheat (fall of 1998), corn, proso millet, and peas were established in 1999. Weed control in each crop was based on prevalent practices used by producers, with the exception that sulfonyleurea herbicides were not used in any crop. At harvest, weed density was recorded in four 0.33 m² quadrats and by the line bead method.

Peas (Profi, a spring variety) will be planted in each plot during early April in 2000. Peas will be harvested based on three management options: green fallow (6-8 inches in height), forage (1/10 flower bloom), or seed production. At harvest for each option, weed density and biomass will be recorded. Herbicides will not be used during the pea growing season; glyphosate will be applied to eliminate weeds present at planting of peas.

RESULTS: Weed density was highest in peas and winter wheat, whereas proso millet was weed free. The predominant weeds were Russian thistle and kochia. The second set of plots for this study have been established in an adjacent field.

FUTURE PLANS: The study is being repeated in 1999-2000. Also, we plan to evaluate this approach with sunflowers.

ESTIMATING SOIL HYDRAULIC PROPERTIES FROM SPARSE DATA

J.G. Benjamin

PROBLEM: Determining soil water characteristics is both laborious and time-consuming, but is necessary for many soil management evaluations and for modeling purposes. Methods need to be developed that give the required information about soil hydraulic conductivity and water retention characteristics but do not need the tedious laboratory or field sampling procedures that are used with current methods.

APPROACH: We used an adaptation of the Gregson-Hector-McGowan (GHM) model of water retention. The GHM model uses information about the relationship between the slope and intercept of a log-log plot of the $\psi(\theta)$ curve to improve predictions of soil water retention characteristics from limited data. Studies have shown that using this method and one $\psi(\theta)$ point can give very good predictions of the entire $\psi(\theta)$ curve. We used an analogous procedure to determine coefficients for unsaturated hydraulic conductivity function based on the slope and intercept of a log-log plot of the $k(\theta)$ curve. The GHM model was fit to $k(\theta)$ data, determined on soil cores by the step outflow method, for 9 medium to fine textured soils from Ohio, Iowa and Colorado. The soils came from various rotation and tillage studies showing a range of hydraulic properties. We used the $k(\theta)$ data from the -20 kPa ψ as the fitting point. Predictions were made from the GHM regression on individual soil cores, from the GHM method using slope-intercept relations for individual soils and from the GHM method using slope-intercept relations for all soils. We computed the coefficients on each soil core for the Campbell equation of hydraulic conductivity to compare the accuracy of the GHM method and a standard model often used in modeling.

RESULTS: There appears to be a common factor for these soils that could be used to predict unsaturated hydraulic conductivity from a paired point on the $k(\theta)$ curve similar to the method used to predict $\psi(\theta)$ by the GHM method. Using the GHM method with coefficients for an individual soil type gave better predictions than using the coefficients based on all soils, but either method was as good or better than the Campbell equation using individual core data. There appeared to be a bias with the Campbell method preventing an accurate determination of $k(\theta)$ properties.

FUTURE PLANS: Hydraulic conductivity and water retention characteristics are measured on soils from other studies as a means to determine soil management effects on the plant root environment. We plan to continue the evaluation of this technique to determine under what soil conditions and management schemes the procedure is valid and under what conditions the procedure fails to give acceptable estimates of water content and hydraulic conductivity.

MANAGING SOIL COMPACTION TO ENHANCE CORN PRODUCTION AND SOIL BIOLOGICAL ACTIVITY

J.G. Benjamin, M.F. Vigil, D.C. Nielsen

PROBLEM: Sustainability of agriculture demands that soil resources remain productive. Degradation of soil resources is of particular interest in the Great Plains because relatively low soil organic matter levels make these soils very susceptible to many adverse soil management effects such as compaction. Most compaction research has addressed changes in soil physical characteristics, but less research has addressed the effects of these physical changes on plant productivity and biological activity. In order to manage compaction, we need information on the soil environment created by varying compaction levels and information on the compaction level tolerated by plants. The goals of this research include: 1) Evaluate current concepts of soil mechanics as related to soil compaction; 2) Gain information about the soil environment and plant response to soil environmental changes caused by compaction to further understand the interaction between the soil and the plant; and 3) Test the effectiveness and longevity of methods to alleviate soil compaction.

APPROACH: We continued a study of soil compaction effects on corn (*Zea mays*, L.) growth and soil biological activity at Akron, Colorado, on a Weld silt loam (fine smectic, mesic Aridic Paleustolls) that was started in 1997. The treatments include 3 levels of wheel traffic (0, 2, and 8 passes of a 7700 kg tractor) and 5 methods of compaction alleviation: 1) no alleviation from tillage; 2) shallow (20 cm deep) chisel plow tillage conducted only at the start of the experiment; 3) shallow chisel plow tillage conducted yearly during the experiment; 4) deep (45 cm deep) chisel plow tillage conducted only at the start of the experiment; and 5) deep chisel plow tillage conducted yearly during the experiment. The field was planted to corn in the spring and plant growth characteristics were measured throughout the growing season to determine compaction effects on corn productivity. We took soil samples in the fall after harvest to determine yearly changes in the soil physical properties (bulk density, soil strength, infiltration, and water retention characteristics) caused by compaction and compaction alleviation.

RESULTS: We found a significant effect from wheel traffic in samples collected before and after compaction in the fall of 1997. Bulk densities from the non-compacted soil were about 1.4, bulk densities from soil with 2 tractor passes were about 1.5 and bulk densities from soil with 8 tractor passes were about 1.6. Changes in bulk density due to wheel traffic were evident only in the surface 1.5 to 8.5 cm depth. Samples collected at lower depths showed no evidence of increased bulk density from wheel traffic. Corn yield differences due to compaction found in 1998 were not as apparent in 1999 and could be caused by a natural alleviation of the soil compaction from wetting-drying and freezing-thawing cycles.

FUTURE PLANS: We will continue the analysis of 1999 growing season data to examine the soil conditions leading to the measured crop yields. We will continue the soil physical property analysis to determine changes in soil properties from one growing season to the next and the effects of overwintering on soil physical conditions. We will continue the experiment in 2000.

EVALUATING AND QUANTIFYING SOIL QUALITY AND PRODUCTIVITY FROM SELECTED SOIL PROPERTIES

R. A. Bowman

PROBLEM: In the semiarid areas of the Great Plains, continued clean-till wheat-fallow cultivation has resulted in significant losses of soil organic matter (SOM) because of wind erosion and decomposition. This loss of SOM results in a deterioration of soil quality and a reduction in crop productivity because of attendant losses in soil physical, chemical and biological properties such as rooting depth, water storage, fertility, and soil aggregation. Factors influencing crop productivity such as pH, SOM, texture, CEC, aggregate stability, and rooting depth (depth of solum or depth to lime) need to be evaluated under similar precipitation conditions to understand more fully yield differences, especially for the same rotation where important soil factors may be spatially different. A need exists, therefore, to develop methodology to assess soil productivity changes using these important soil factors in a multiple regression analysis.

APPROACH: The intent is to develop a quantitative index (multiple correlations) to assist in the prediction of soil quality and crop productivity (cumulative grain or biomass yield of rotation). Index will integrate differences in SOM, pH, texture, CEC, and rooting profile. SOM, clay and silt, bulk density (BD) and depth to lime (solum) are measured for a stratification depth (0-2"), a fertility index depth (0-6"), and for a 24" and solum (A and B horizons) depth. Thus, a Soil Productivity Index (SPI) can be developed based on best correlations of the SPI with the various soil depths and soil properties. Additionally, a structural index (S_s) based on ratio of SOM % to clay % can also be assessed to determine potential for soil degradation. Indices for new crop rotations can then be compared to indices from the traditional winter wheat-fallow, or with soils from an adjacent native sod of the same soil series.

RESULTS: This project was initially carried out in cooperation with the NRCS Soil Quality Team at Akron. This team has since been reassigned away from the area of on-farm soil quality assessment and evaluation. Data for soil organic carbon, particulate organic matter carbon, texture, and depth to lime have been collected. The SOC data showed only a 6% increase in SOC from W-F versus continuous cropping at the 0-24 inch depth. However, this value was 25% for the 0-2 inch depth, 13% for the 0-6 inch depth, and 9% for the 0-12 inch depth. Our 12-inch depth value for SOC coincided closely with data obtained by Duran and coworkers who collected SOC data for 5 network sites. With respect to normalized biomass yield, the W-F was less than the other longer rotations which were all the same. Differences were due to low biomass values for conventional-till wheat and sunflower in the W-S-F rotations. Wheat biomass in W-C-M was also low.

FUTURE PLANS: While there is a much greater interest in SOM now than 10 years ago, emphasis is on longer reduced- or no-till rotations and less fallow to increase residue which will ultimately conserve more water, reduce erosion, and increase productivity. Field measurements for compaction, infiltration, presence of earthworms, pH, salts, and nitrates, in addition to SOM, will continue on selected farmers fields for direct comparison of W-F with longer reduced-tillage rotations.

SOIL ORGANIC MATTER CHANGES UNDER ALTERNATE CROPPING AND TILLAGE SYSTEMS

R.A. Bowman, M.F. Vigil, R.L. Anderson, D.C. Nielsen, J.G. Benjamin

PROBLEM: Soil organic matter is important to hold the soil together, to easily infiltrate water, to reduce compaction, and to provide nutrients such as N, P, K, S, and micronutrients. However, the conversion of Great Plains grassland to clean-till small grain farmlands since the mid 19th century has resulted in extensive loss of the native SOM because of wind erosion and decomposition. On a global basis with about 40% more organic carbon residing in the SOM than in the terrestrial plant biomass, it is easy to see how the conversion of grassland to wheat-fallow could create over time a drop in crop production and a significant increase in global CO₂. On the other hand, if we intensify the cropping system over the WF, and minimize soil disturbance through less tillage, and if we manage water, fertilizer, and pests efficiently, we should be able to reverse SOM loss and increase soil productivity. Our objective, therefore, was to evaluate different cropping systems for their efficiency in water and nutrient use, minimal soil erosion, minimal chemical leaching, and organic matter buildup. This report focuses on changes in SOM.

APPROACH: The study is located at Akron, CO on a predominantly Weld silt loam. Three replications of 60 combinations and permutations of cropping and rotation sequences exist (See report by Anderson, Nielsen, Bowman, and Vigil for treatments). Extensive sampling was conducted on all 180 sites for soluble (dichromate oxidation) and total SOM and POM and total organic C and N (C-N analyzer). Soil samples were collected at 0-2 inch, and at 2-6 inch depths for pH and nutrient stratification and for plow layer evaluations especially under the no-till conditions and mixing under conventional-till. Soil samples on different soil series were taken to 5 feet depth. Some measure of aggregate stability against wind erosion is assessed. Cumulative OM Index (COMI) and solum SOM will be assessed every 3 to 5 years.

RESULTS: Specific data set have been collected as part of a regional project on maintaining or improving soil quality, and consequently, crop productivity, in the Great Plains. Data on SOC, POM-C, Total N, inorganic N, pH, and EC were collected for two contrasting rotations at all network sites. We compared W-F to W-C-M. At the 0-6 inch depth, the SOC in WCM was 19% greater (0.81% versus 0.68%). No differences were found for the 6-12 and 12-24 inch depths. For inorganic N, no significant differences were observed. A few samples from both treatments, however, did contain > 20 ppm nitrate-N (40 lb N) at the 6-12 inch depth. Soil reaction (pH) was lower in the W-C-M because of the continuous N fertilization.

FUTURE PLANS: Since rotations have been established for over 8 years, we will continue to monitor SOM changes and stabilized or humic carbon (E6/E4 spectrophotometric ratios) for losses or gains with more intensive rotations relative to the conventional winter wheat-fallow rotation which receives less carbon inputs. The relationship between surface crop residue and roots to six inches relative to SOC and POM-C will also be investigated, but only on limited sample set because of the destructive nature of root sampling.

NUTRIENT, CEC, AND pH CHANGES UNDER ALTERNATE CROPPING SYSTEMS

R.A. Bowman, M.F. Vigil

PROBLEM: No-till systems usually conserve more moisture than clean-till systems, especially when weeds have been controlled. The extra available water invariably results in greater yield benefits from N and P fertilizer, with corn requiring more water and fertilizer than wheat because of its higher dry matter production (50 bushel dryland wheat requiring about 75 kg N and about 12 kg P, with 80 bushel dryland corn requiring about 80 kg N and 18 kg P / ha). The role of water and nitrogen is being studied for efficient use. As cropping continues, other nutrients such as P and micronutrients which are seldom replenished, may become deficient. This need becomes even greater in the eroded areas of the Plains where P is chemically fixed by free lime, and where high P applications may also induce Zn and Fe deficiencies. The objectives of the research, therefore, are to evaluate nutrient availability and cycling under WF and alternate cropping systems where more residue is returned to the soil surface, and consequently, more nutrients recycled from within the soil profile. Information is needed for P, S, and Zn use efficiency for subsequent crops such as corn and millet or oil crops or legumes after wheat in a reduced-till rotation.

APPROACH: In a Weld silt loam, various nutrient parameters were measured at the 0-2, 2-6, and 6-12 inch depths to assess availability and cycling in selected plots from our alternate cropping and tillage system study (ACR). These parameters included available P pools such as those extracted by bicarbonate and anion-exchange resins, total soil P, and total soil organic P, residual P and phosphatase activity which is a measure of quickly available organic P. Available S and micronutrients were also evaluated in the surface 6 inches. Because of yearly N applications in continuous cropping systems, pH and CEC changes were also assessed. We also are assessing S levels because of our oil crops, and Zn because of corn.

RESULTS: A paper was prepared for the Great Plains Soil fertility Conference in Denver. Data were collected from a set of 40 soils previously used in SOM studies with four different cropping intensities. Data showed significant responses of cropping intensity to pH, exchangeable Ca and K, and extractable Zn, Fe, and Mn at the 0-6 inch depth, but no differences at the 6-12 inch depth. Soil CEC and sulfate did not show any significant differences. In general, differences were due to soil changes created by continuous cropping systems, which received greater fertilization and produced more biomass per unit time than fallowed systems. Present data seem to indicate that these non-fertilizer applied nutrients exported in the grain are not yet limiting production because of recycling through crop residues, and the sufficiency of the CEC and nutrients in the original soil. However, this needs to be verified with some fertilization studies.

FUTURE PLANS: We will continue to monitor nutrient data on ACR plots since we are only resupplying N and P. The role of residue in buffering pH changes (cation production), and in resupplying the other nutrients are still factors for future considerations. We do need to initiate work on S and Zn in the future, but probably on plots (sunflower and corn) outside of the ACR, in areas where SOM is low, and soil may be sandy. We will be doing a grid sampling for SOM, texture and pH on all research areas, so samples can be monitored for S and Zn also.

ORGANIC MATTER AND NUTRIENT CHANGES IN SIMULATED EROSION STUDIES

R.A. Bowman, M.F. Vigil

PROBLEM: Soil erosion is a serious problem in the Semiarid Plains. Its effects on water storage and nutrient availability have been extensively studied. Restoration with fertilizer or manures, and its effects over the long term are less well understood. Greb originally, and Smika later, conducted studies in the mid-50s with simulated erosion plots (different amounts of top soil removed) and added fertilizer. They removed from zero to 38 cm (15 inches) of top soil across the field. They were using added fertilizer to replace eroded topsoil in maintaining grain yields. We are presently revisiting these sites to evaluate long-term changes in selected chemical and physical properties (1956 vs 1996), and to assess presently, water use, crop yield and restoration potential of SOM with different fertilizers and amendments under more intensive and diverse cropping than the traditional wheat-fallow.

APPROACH: Hairy vetch was seeded as green manure in the spring on half the plots in an alternate vetch-no vetch format across the simulated erosion gradient. After 4 weeks, roundup was applied to kill cover and conserve water. In the fall prior to wheat seeding, a high rate of P (60 lb P₂O₅/acre), and a low rate (15 lb P₂O₅/Acre) were applied across the simulated erosion gradient so that both rates of P were contained in the vetch and in the no-vetch plots. The P as 11-52-0 was surface broadcast for the high rate (45 lb) and banded with the seed (15 lb) for the high and low rates. After wheat seeding soil samples were taken to assess P distribution for high and low P levels from fertilizer across the simulated erosion gradient which also created a calcium carbonate gradient. Wheat seedling biomass and P concentration aboveground for these areas were also assessed before the first frost.

RESULTS: Depth of soil or amount of top soil removed influenced water use and nutrient use significantly, and wheat grain yields were a function of soil depth. While there was trend for greater P uptake where more P was applied in subplots, overall data did not show any significance, and yield differences were due primarily to soil removal.

FUTURE PLANS: The Greb plot area will be used as a test plot for various spring and summer crops such as vetch, peas, sunflower, and wheat. Part of the sunflower plot will receive sulfur fertilizer, and part will not, so we can obtain some data for yield of an oil crop where SOM is low (12-15 inches of soil removed). Zinc and iron response will also be evaluated with corn. Data on changes in soil properties from the original Greb paper in 1968 will be compared and evaluated for publication.

ADSORPTION, MOVEMENT, AND TRANSFORMATIONS OF MANURE-P AND ORGANIC-P IN SOILS

R.A. Bowman, M.F. Vigil

PROBLEM: Phosphorus is the second most important soil element for plant growth. Many areas within the Great Plains are deficient in P, so its excess and waste have never been a concern. A serious problem within the Great Plains, though, has always been soil erosion, and secondarily, its association with P removal. This problem is magnified when eroded P has the potential to enter surface waters and cause eutrofication. This concern, however, is attenuated by the fact that, generally, P loading in our soils is minimal, and consequently, its removal and discharge into surface waters do not present a serious problem. This situation may change, however, with the advent of large animal containment areas, and the need to use and dispose of the animal waste and the excess P generated by these large Units.

APPROACH: A need exists, therefore, to assess the potential of these relatively low-P soils to fix and release organic (Po), and inorganic P (Pi), and manure-P. Our objectives were to assess: 1) P adsorption isotherms and buffering capacity (PBC) of soils with varying physical and chemical properties, 2) differences in adsorption potential for Pi and Po with potassium phosphate monobasic (KH₂PO₄), ammonium polyphosphate (10-34-0), phytic acid (Ca-inositol hexaphosphate), and beef and hog manures, 3) movement of P with above substrates in small columns, and 4) mineralization and transformations of above substrates.

RESULTS: Data showed the PBC to be essentially a function of the reactive surfaces in the soil with the calcareous silty loam soil having the largest P buffering capacity and the sandy loam soil the least. More P was also fixed when P was added with water to near 1/3 bar and dried for 3 days. Thus, less P was solubilize with more clay, and with greater residence time and mixing. Data also showed that polyphosphate from 10-34-0 fertilizer is preferentially adsorbed to orthophosphate which is the normal P form in fertilizer. Downward movement of P occurred primarily in sandy soils with water-soluble Po mostly, but most of the P was still in the top ½ inch of the profile. Inorganic P in manures appears to behave similarly to inorganic P in fertilizers. Phytate P is readily precipitated and fixed in a ca-dominated system. Anion-exchange resin strips for available P assessment and rapid P desorption may serve as a good indicator for potential P pollution problems. Mineralization of P substrates was difficult to evaluate because of the confounding from large amounts of native inorganic P.

FUTURE PLANS: Manure samples (beef and hog) will be evaluated for various forms of P, and for their ease for extractability with and without soils. Different extractants such as water, and dilute acid and base, and successive extractions (water then acid then base) will be tested to remove the various P forms. Extractability of added P after various resident times of drying of soil will also be evaluated. P removal and correlation with selected soil test indices will also be evaluated.

AGRICULTURE AND BUSINESS MANAGEMENT ACTIVITIES IN NORTHEAST COLORADO

D.A. Kaan

Cost of Production Studies: Cost of production studies have been completed for Northeastern Colorado and the Golden Plains Area counties this winter. These studies have been completed for dryland crops including winter wheat, corn, millet, and sunflowers. Irrigated crops include winter wheat, corn, dry beans, alfalfa, potatoes and sugar beets. Data collection for these studies was achieved through individual surveys with producers throughout Northeastern Colorado. Typical crop enterprises were defined for each crop based on the survey data collected. These cost of production studies will be published in the 2000 Golden Plains Area Agricultural Handbook.

Beef Education and Economic Forum (BEEF) Standardized Performance Analysis (SPA): Beef Education and Economic Forum is a three-year program based on the principles of the Integrated Resource Management Program. BEEF is a producer-led, producer-driven program that offers educational opportunities in the form of educational programs, Standardized Performance Analysis programs and a Feedlot Discovery process. Standardized Performance Analysis is an analysis tool for cow/calf producers to evaluate production and financial efficiency measures for the cow/calf enterprise. Ten producers in Northeastern Colorado participated in the SPA program in 1999, the first year of the BEEF project. The average weaning percentage for these producers was 92 percent with an average weaning weight of 560 pounds per calf. The average annual cow cost was \$525.00 per cow. The average return on assets for these producers was 5.85 percent.

Risk Management Education: Risk management education under funding received from USDA and CSREES is on going in Colorado. On a regional basis, Montana, Wyoming and Colorado have teamed together and pooled these seed money allocations to each state to increase the effectiveness of programming efforts. A risk management resource notebook entitled "Risk and Resilience in Agriculture" has been produced over the past year. Contents of this resource book to date are based on results from the risk management needs assessment survey that was completed in 1999. These notebooks will be distributed to county extension offices throughout the three states. In the future, Risk Management Clubs will be organized and supported as local demand warrants. The notebook will be distributed to these clubs also.

ECONOMIC INJURY LEVEL OF RESISTANT AND SUSCEPTIBLE WINTER WHEAT VARIETIES TO RUSSIAN WHEAT APHIDS

M.D. Koch

PROBLEM: Several hard red winter wheat varieties have been successfully introduced to area producers with the ability to resist toxins injected while Russian wheat aphids (RWA) feed on the growing plants. Plant breeders are constantly inserting genes into winter wheat plants to produce a plant totally unaffected by the presence of this damaging aphid. This experiment is designed to determine the amount of susceptibility by each variety with a resistant gene inserted into the profile.

APPROACH: The Central Great Plains Research Station near Akron, Colorado was the location for this experiment. Soil type is a Weld silt loam. A complete randomized block design was used to compare a susceptible variety to three varieties with differing resistant genes. The susceptible variety was TAM 107. It was compared with TAM 107 R3 and two advanced lines being called Dn5 and Dn6. Plot size was six feet long by six feet wide. The plots were planted on twelve inch centers using a small plot cone planter with disc openers. The center two rows of each plot were paired for analysis. One of the rows was to be used for destructive sampling and the other row for yield. The plots were infested with RWA using the bazooka method. The three infestation levels were no aphids, 1X, and 10X. Due to high winds, infestation was done three different times. The first infestation was 2 April 1999 with 48.2 RWA applied to the 1X rate and 181.0 at the 10X rate. The second bazooka application was conducted on 7 April using 22.1 RWA on the 1X and 231.6 on the 10X rate. Finally, 20 April the bazooka was used to introduce another 68.0 RWA on the 1X plots and 289.9 on the 10X plots. The total aphids applied to the 1X rate plots was 138.3 while the 10X rate received 702.5 per plot.

Destructive sampling for each plot began when all plots had reached Zadoks growth stage 35. Actual growth stages were Zadoks 35 to 40 depending upon variety and moisture available for spring regrowth. One half of the row meter for each plot was sampled and brought in for analysis on 10 May, 1999. Total number of tillers were taken and divided into four categories. They were as follows: RWA asymptomatic and no RWA, asymptomatic with RWA, symptomatic with no RWA, and symptomatic with RWA. The tillers in each category were counted and immediately placed in Berlese funnels for 24 hours. The total number of RWA was counted from each sample. The second half of the row meter was destructively sampled on 3 June as each plot reached Zadoks growth stage 55. Actual growth stage from each of the plots was 58 to 65 depending on variety. Data was collected precisely as the first sample date.

Harvesting of the experiment was done on 8 July, 1999. The yield row meter was clipped with scissors just below the head. Each head was counted and placed in a small paper bag. Thrashing began on 14 July using an Agriculex SPT-1 separating machine. When thrashing was completed, each sample was cleaned using a small Rapsco aspirator. Next, the total seed weight for each plot was taken to the nearest hundredth of a gram. A sub sample of one thousand seeds was taken using a model 850-2 seed counter manufactured by The Old Mill Company. This sub sample was weighed to determine test weight.

RESULTS: Preliminary results show the resistant varieties to be well adapted to the climate and forgiving of aphid pressure. All data for this study are being analyzed by Dr. Frank Peairs of the Bioagricultural Sciences and Pest Management Department at Colorado State University, Fort Collins, Colorado.

ECONOMIC INJURY LEVEL OF RESISTANT AND SUSCEPTIBLE FEED BARLEY VARIETIES TO THE RUSSIAN WHEAT APHIDS

M.D. Koch

PROBLEM: Beef producers in Colorado and neighboring states successfully raised feed barley for many years. When the Russian wheat aphid (RWA) entered the region in 1986, barley was targeted by the pest. Test weight and yield are reduced substantially by the feeding of this aphid. As a result, many producers were forced to raise other crops for livestock feed. An attempt was made by plant geneticists and breeders to make barley varieties resistant to the aphid.

APPROACH: Plots were established in five locations throughout eastern Colorado. There were three managers for the five sites. This report will focus on two sites. They were located on the Don Mais farm east of Stoneham, Colorado and the other at the Central Great Plains Research Station east of Akron, Colorado. The three remaining sites were at Fort Collins, Briggsdale, and Lamar, Colorado. The plot configuration was of a complete randomized block with six replications. Five varieties of feed barley were tested. The varieties were as follows: Otis (control), Otis treated with Gaucho (level of resistance indicator), 95 RWA 82, 95 RWA 104, and 95 RWA 249. Each plot was 50 feet long by six feet wide. Seeding rate was 80 pounds per acre. A small plot cone planter was used with disc openers to ensure uniform seeding depth and distribution. The planting date for both plots was 17 March 1999. Natural infestations were relied upon for this experiment.

Each site was sampled at the late boot stage of growth for Russian wheat aphids. The Akron site was sampled on 21 June and the Stoneham site on 22 June 1999. Each plot had twenty random tillers collected and placed in sealable plastic bags. The samples were brought into the laboratory and the tillers for each plot were counted and sorted into four categories. The categories were as follows: symptomatic with RWA, symptomatic without RWA, asymptomatic with RWA, and asymptomatic without RWA. Then the samples were placed in Berlese funnels for 24 hours. Then the total number of RWA in each row meter was counted. Aphid pressure at both sites was high.

A Wintersteiger Elite 2000 small plot combine was used at each location for harvesting. The entire plot was harvested and put into seed bags for cleaning and analysis. The date for harvest at Akron was 29 July and Stoneham was 17 August 1999. Delays in harvest at the Stoneham site were caused by drought at planting as well as rainy weather at seed maturity. The poor plant stands and the precipitation caused a flush of weeds, which needed to be controlled before harvesting. A backpack sprayer was used with 2.5 pints of Paraquat dichloride to burn down the weeds.

RESULTS: The varieties with the Russian wheat aphid resistant genes inserted into them did not perform well. The dry conditions at planting and the heat during seed ripening adversely affected both yield and test weights in these varieties. Yields for Otis treated with Gaucho nearly doubled the best resistant variety in this test. Also, the check plots using Otis barleys were extremely damaged by the aphid feeding and still consistently yielded better than the resistant varieties. Therefore, efforts are being made to insert resistant genes into the Otis variety. This will allow producers to use a climatically proven variety without having to use chemicals to control the Russian wheat aphid.

EVALUATING THE EFFICACY OF ADAGE AS A SEED TREATMENT FOR MANAGEMENT OF SUNFLOWER STEM WEEVIL, SUNFLOWER ROOT WEEVIL AND *Pelochrista womanana*

S. Pilcher, D. Kennedy, B. Filla, L. Charlet, M.D. Koch

PROBLEM: Seed treatments used as preventive control measures for pests could assist sunflower producers with time management.

APPROACH: The Adage treatments studied were selected due to a new seed coat formulation introduced by Novartis which may increase the systemic activity of the product. Plots were two rows by 50 feet arranged in four replicates of a randomized complete block design. Seed treatments were planted on 19 May 1999 with a John Deere Maxi-Merge planter. Spotted stem weevil densities were one adult per two plants on 2 July 1999. On 2 September 1999, five plants per plot were dissected and the sunflower stem weevil larvae in the lowest 18 inches of each stalk were counted.

RESULTS: Sunflower stem weevil, *Pelochrista womanana* (root infesting moth larvae), and stem diameter was subjected to analysis of variance and mean separation by Dr. Larry Charlet. The method used was Duncan's multiple range ($\alpha=0.05$). Results showed no significant differences between seed treatments and the untreated control. This would indicate the seed treatments had no effect on stem weevil populations within stalks. There was a block effect with stem weevil densities increasing from block one to block four. Sunflower stem diameter was not significantly different (Table 1).

The middle rate of Adage (400gm) did significantly reduce densities of *Pelochrista womanana* (root infesting moth larvae) compared to the untreated control. It is unclear why the high rate of Adage (500mg) did not provide a similar effect. The economic injury level for this pest based on larvae per plant has not been determined (Table 1). Sunflower root weevil (*Baris strenua*) densities were five to seven larvae per plant with no numerical differences observed between seed treatments and the untreated control. The economic injury level of this pest based on larvae per plant is not known. No phytotoxicity was observed with any of the treatments.

Table 1. Evaluating the efficacy of *Adage* as a seed treatment for management of sunflower stem weevil and *Pelochrista womanana* . Central Great Plains Research Station, Akron, CO. 1999

Treatment	Number of Stalks	Stem Diameter	No. stem weevil per stalk		No. <i>Pelochrista womanana</i> larvae per stalk
			Mean	Range	
Control	40	1.72 a	27.3 a	3-107	7.10 a
Adage 300 gm	20	1.74 a	19.8 a	4-53	6.40 ab
Adage 400 gm	20	1.76 a	22.2 a	6-67	4.90 b
Adage 500 gm	20	1.82 a	29.2 a	6-67	6.70 ab
F-Value		1.08	1.69		2.52
p>F		0.3616	0.1746		0.0628

Means followed by same letter(s) in a column are not significantly different Duncan's multiple range method ($\alpha=0.05$)

CONTROL OF SPOTTED SUNFLOWER STEM WEEVIL WITH PLANTING AND CULTIVATION TREATMENTS

S. Pilcher, D. Kennedy, M.D. Koch

PROBLEM: Treatments applied at planting are considered to be preventive control measures. The ability to apply chemicals to control the Spotted sunflower stem weevil at cultivation would allow producers to adjust input costs according to need.

APPROACH: The experiment consisted of plots which were single rows by 50 feet buffered by single non treated rows. They were arranged in four replicates of a randomized complete block design. The planting time treatment was applied on 19 May 1999 with a John Deere Maxi-Merge planter. It was equipped with a CO₂ powered, micro-tube injection unit directed into the seed furrow ½ inch above the seed. Cultivation treatments were applied on 2 July 1999 at the V6 to V8 plant growth stage with a CO₂ powered sprayer with an over-the-whorl nozzle (8003 VS- TJ) positioned 6 inches over the plant whorl mounted on a Orthman cultivator. All cultivation treatments were 12 inch band applications. At the time of cultivation, spotted stem weevil densities were one adult per two plants. On 2 September 1999, five plants per plot were dissected and the sunflower stem weevil larvae in the lowest 18 inches of each stalk were counted.

RESULTS: Stem weevil larvae counts were subjected to analysis of variance and mean separation (Table 2.) by Student-Neuman-Keuls method ($\alpha=0.05$). All treatments reduced spotted sunflower stem weevil densities. Foliar and planting time Furadan 4F treatments at 1.0 lb active ingredient/acre significantly reduced stem weevil densities as compared to all other treatments. The economic injury level for this pest is not known. It is known to be affected by stalk diameter and the presence of Phoma black stem disease. This disease was noted in the untreated control plots at low levels. No phytotoxicity was observed with any treatment.

Table 2. Control of spotted sunflower stem weevil with planting and cultivation timed treatments, Central Great Plains Research Station, Akron, CO, 1999

Treatment, lb AI/acre	Timing	SSW ¹ Larvae/Plant	% Control	% Lodging
Untreated		18.20 a	---	26.8
Mustang 1.5E, .03	Cultivation	10.20 b	44	15.6
Furadan 4F, .75	Cultivation	9.95 b	45	13.2
Baythroid 2E, .02	Cultivation	7.30 bc	60	11.4
Mustang 1.5E, .045	Cultivation	6.10 c	66	9.6
Baythroid 2E, .03	Cultivation	5.75 c	69	7.2
Warrior 1E, .02	Cultivation	5.70 c	69	7.8
Warrior 1E, .03	Cultivation	5.15 c	72	8.0
Furadan 4F, 1.0	At-Plant	1.15 d	94	2.2
Furadan 4F, 1.0	Cultivation	0.95 d	95	3.0
F value		30.615		
p>F		0.0001		

¹ Means in the same column followed by the same letter(s) are not statistically different, SNK ($\alpha=0.05$).

EFFECTS OF CROPPING ROTATIONS ON BENEFICIAL AND PEST INSECTS

M.D. Koch

PROBLEM: In 1986 the Russian wheat aphid (RWA) became a major small grains pest in Colorado. Control methods for this pest include cultural, mechanical, chemical, and biological. Russian wheat aphid control has been most effective using chemicals. However, producers may be able to combine cultural and biological techniques to decrease the need for other costly control measures. This would also diversify production on a given farm. Crops grown in close proximity to one another providing a year-long host of green vegetation may allow predators and parasites to survive and control pests.

APPROACH: The plots were established in the spring of 1996. The previous crop was corn with a small area used for sunflowers. Crop rotations were selected for research based on area production practices. The rotations used are as follows: winter wheat-fallow; winter wheat-corn-fallow; winter wheat-corn-millet; and winter wheat-corn-sunflower-fallow. The individual plots are large at 90 feet wide by 180 feet in length. Experimental layout was in a complete randomized block with four replications. Each phase of the rotations is present every year. This results in twelve plots per replicate. Each of the wheat plots is divided in half lengthwise. One half is a susceptible variety and the other a variety resistant to the Russian wheat aphid. The varieties used in 1999 were TAM 107 as the susceptible and Halt as the resistant.

Wheat was planted on 30 September 1998 with a John Deere 750 no-till drill. The planting rate was 60 pounds per acre. Fertilizer was applied at planting in a band above and to the side of the seed. Fertilizer rates were 45 pounds of nitrogen and 20 pounds of phosphorus. The formulations used were liquid 10-34-0 and 32-0-0 which were banded using separate tubes. No herbicides were used during the growing season.

Corn was planted on 19 May 1999 using a John Deere max-emerge planter. The planter was six rows wide and delivered 16,100 seeds per acre. The variety used was Dekalb DK 493RR. Fertilizer was applied at planting using 98 pounds of nitrogen and 20 pounds of phosphorus per acre. Formulations were liquid 32-0-0 and dry 0-46-0 being banded above and to the side of the seed. Field sandbur *Cenchrus incertus* was prevalent in the weed seed bank prior to the establishment of the plots. This is why a Roundup Ready corn variety was selected. An application of Prowl 3.3EC *Pendimethalin* and AAtrex 4L *Atrazine* at one quart per acre each was used to keep Roundup applications minimal. The application was made on 12 May. Producers in the area use the corn stalks for cattle feed. Label restrictions allow no more than 32 ounces of Roundup applied to the growing corn if the stalks will be used for feed. This, along with problems getting the seed, was why the Prowl and Atrazine were applied prior to planting.

Sunup proso millet was planted in 08 June 1999 using a John Deere 750 no-till drill. Thirty-five pounds of nitrogen was applied at planting. The liquid 32-0-0 was applied in the seed furrow with 15 pounds per acre of millet. Poor plant stands due to 1.54 inches of rain before emergence forced the replanting of replicates three and four. Replanting was done at 10 pounds per acre of seed on 01 July. The plots remained free of weeds with the application of seven ounces per acre of Clarity *Diglycolamine salt* and four ounces of Weedone Lo Vol 6 *2,4-Dichlorophenoxyacetic acid* on 01 June. Final stands in all plots were good.

Sunflowers were planted on 07 June 1999 using a six-row John Deere max-emerge planter. Triumph 545 was the variety used. Fertility was enhanced with 40 pounds of nitrogen and 20 pounds of phosphorus. The liquid fertilizers used were 32-0-0 and 10-34-0 which were banded two inches above and two inches to the side of the seed. A new chemical was used to control weeds. The chemical is Spartan *Sulfentrazone* which was applied at a low rate of 5.3 ounces per acre. Soil pH averaged 7.1 and resulted in stand loss from the herbicide. Numerous producers in the area had various degrees of stand loss from the use of this chemical as well. Rainfall crusted the soil surface which also decreased the possibility of plant emergence. The crop was replanted with the same seeding rate on 22 June. Final stand counts showed losses from the herbicide to be severe with less than 20 percent survival.

All fallow plots are treated as no-till except the winter wheat-fallow rotation which is conventionally tilled. Roundup *Glyphosate* was used to control weeds in the no-till plots when needed. Conventionally tilled plots were treated with Roundup on 09 May 1999 using a Tyler Patriot sprayer at 10 gallons of mix per acre. Each plot was then tilled with a tandem disc on 07 June and sweep plowed with treaders on 15 July.

RESULTS: Yields were above average for all crops this year. Soil moisture was good throughout the wheat ripening period as well as the remainder of summer and into the fall. Wheat yields averaged 40.88 bushels per acre for all rotations. TAM 107 outperformed the Halt with averages of 42.61 and 39.14 respectively. All yields were higher in the wheat-fallow rotations. The average for this rotation was 53.22 bushels per acre. The wheat-corn-sunflower-fallow rotation yielded the least with an average of 34.29 bushels per acre. The other two rotations were similar in yield with an average of both at 38 bushels per acre.

Wheat pests were present in low numbers through the entire growing season. Mites and aphids were the prevalent insect pests. Neither accounted for any economic damage. Russian wheat aphids per 100 random tillers did not exceed nine when put in Berlese funnels for 24 hours. Cutworms were found at several locations but did not approach treatment levels. A total of three Pale western cutworms *Agrotis orthogonia* were found and four Army cutworms *Euxoa auxiliaris*.

Corn plots were good with an overall average of 77.58 bushels per acre. The wheat-corn-fallow rotation yielded the least with an average of 70.95 bushels per acre. The other rotations of wheat-corn-millet and wheat-corn-sunflower-fallow had yields of 77.00 and 84.80 respectively. Since the rotations are beginning the second year for each crop, rotational effects on yields will become more apparent this coming year. Large variations in crop yields are not caused by the rotations at this time. Rather, it is thought to be influenced by location of the plot within the experimental area. The area is relatively free of slopes but is subject to water runoff.

Millet yields were consistent from one plot to another. This was a surprise given that replicates one and two were replanted. Average yield for all plots was 46.1 bushels per acre. The low yield was 43.01 in plot 409 and the high was 48.87 in plot 308. Very little pest pressure was observed through the growing season. Onion thrips *Thrips tabaci* Linderman, were present all season. However, no damage was seen on the plants. Greenbugs and Bird-cherry oat aphids were also noted. The number of aphids was well below economic thresholds.

Sunflower plots were not taken to yield. Final stand counts were poor with less than 600 plants per acre. No entomological data was collected from the plots. The Spartan herbicide controlled weed pressure. It is hoped FMC Corporation will develop this herbicide for use in high to moderate pH soils.

FORAGE AND SEED YIELD OF SEVERAL PEA AND SOYBEAN VARIETIES

D.C. Nielsen

PROBLEM: Diversifying dryland production systems in the central Great Plains requires knowledge regarding the productivity of alternative crops. Producers have shown interest in both forage and seed production of soybean and pea, yet seed yield and forage yield and quality information is not available.

APPROACH: One Pioneer (P) and 4 Asgrow (A) soybean varieties (maturity groups 2.9 to 4.3), and one pea variety (Arvika) were evaluated for seed yield and forage yield and quality. Six other pea varieties were evaluated for seed yield. Arvika and Profi pea and the Pioneer soybean were also evaluated under a gradient irrigation system to test for variable response to water. Planting dates and rates and harvest dates are given in the table below. Seeding was done with a JD 750 drill with 15 in. row spacing.

RESULTS: Above normal precipitation resulted in good forage and seed yields, and forage quality was good for all soybean varieties and the one pea variety tested. Soybean varieties suffered from spontaneous pod opening during warm, dry fall afternoons, resulting in significant seed loss (see Shatter Loss column). Use of a stripper header resulted in very low mechanical harvest losses of soybean.

	Planting Date	Forage Harvest Date	Seed Harvest Date	Forage Growing Season Precip (in)	Seed Growing Season Precip (in)	Planting Rate (seed/a)	Final Plant Stand (pl/a)	Forage Dry Weight (lb/a)	Moisture at Forage Harvest (%)	Crude Protein (%)	NDF (%)	ADF (%)	TDN (%)	RFV	Seed Yield (bu/a)	Shatter Loss (bu/a)
Soybean																
P 9294	24 May	27 Aug	24 Sep	11.65	13.79	165000		5398	67	15.0	37.1	30.8	65.8	163	30.6	15.3
A 3302	24 May	3 Sep	6 Oct	13.38	14.97	165000		5076	71	14.8	35.4	29.6	67.1	173	29.5	10
A 3701	24 May	3 Sep	6 Oct	13.38	14.97	165000		4831	71	15.6	36.3	29.0	67.7	170	31.9	9.7
A 3901	24 May	3 Sep	6 Oct	13.38	14.97	165000		4028	72	15.6	35.8	30.1	66.5	170	32.5	8.7
A 4301	24 May	13 Sep	12 Oct	13.38	15.30	165000		4448	68	15.5	36.1	29.2	67.5	171	27.1	5.4
Pea																
Arvika	31 Mar	29 Jun	3 Aug	7.86	10.93	128	396500	3518	77	16.8	32.9	27.4	69.4	191	1065	
Profi	31 Mar		3 Aug		10.93	180	439000								1752	
Alfetta	1 Apr		3 Aug		10.93	180	283200								2114	
Majoret	1 Apr		3 Aug		10.93	180	318700								1838	
Integra	1 Apr		3 Aug		10.93	180	226600								1796	
Atomic	1 Apr		3 Aug		10.93	180	240800								1907	
Carneval	1 Apr		3 Aug		10.93	180	332800								1712	

Arvika pea forage dry weight under the irrigation gradient ranged from 3000 to 4500 lb/a for a water use range of 8 to 11 in. Pioneer 9294 soybean forage dry weight 2500 to 4200 lb/a for a water use range of 18 to 25 in. We are unsure why the irrigated soybean forage yield was lower than the dryland forage yield shown in the table above. Profi pea seed yield ranged from 1500 to 2500 lb/a for a water use range of 8 to 15 in.

FUTURE PLANS: The trials will be run in the same manner next year.

CROP ROTATION AND TILLAGE EFFECTS ON WATER USE AND YIELD OF ALTERNATIVE CROP ROTATIONS FOR THE CENTRAL GREAT PLAINS

D.C. Nielsen, R.L. Anderson, R.M. Aiken, M.F. Vigil, R.A. Bowman, J.G. Benjamin

PROBLEM: Increased use of conservation tillage practices has made more soil moisture available for crop production in the central Great Plains, thereby providing greater opportunities for more intensive crop production as compared with conventional wheat-fallow. Information is needed regarding water use patterns, rooting depth, water use/yield relationships, precipitation storage and use efficiencies, and water stress effects of crops grown in proposed alternative rotations for the central Great Plains.

APPROACH: Six rotations [W-F(CT), W-C-F(NT), W-C-PEA(RT), W-SUN-F(RT), W-M-SUN-F(RT), W-SUN-M-PEA(RT)] are used for intensive measurements of water use and water stress effects on yield. (W:winter wheat, C:corn, F:fallow, M:proso millet, SUN:sunflower, PEA:pea CT:conventional till, RT:reduced till). Measurements include soil water content, plant height, leaf area index, grain yield, residue mass and cover, and precipitation.

RESULTS:

Rotation	Crop	ET (in)	Yield (lb/a)	Rotation	Crop	ET (in)	Yield (lb/a)
W-F(CT)	wheat	13.1	2104	W-C-PEA(RT)	corn	16.2	2075
W-C-F(NT)	wheat	15.3	2722	W-C-F(RT)	corn	16.4	4710
W-C-PEA(RT)	wheat	11.2	1773	W-SUN-F(RT)	sunflower	13.6	790
W-SUN-F(RT)	wheat	11.3	1525	W-M-SUN-F(RT)	sunflower	14.1	985
W-M-SUN-F(RT)	wheat	13.4	1756	W-SUN-M-PEA(RT)	sunflower	14.4	1177
W-SUN-M-PEA(RT)	wheat	10.9	1505	W-M-SUN-F(RT)	millet	11.7	2367
W-SUN-M-PEA(RT)	pea	8.8	628	W-SUN-M-PEA(RT)	millet	11.0	1931
W-C-PEA(RT)	pea	9.3	808				

INTERPRETATION: Very dry conditions (less than 30% of normal) for April, May, and June combined with greater than 30% higher precipitation in July and August resulted in higher yields for corn, sunflower, and millet than predicted by previously established yield/water use relationships. As in 1997, wheat yields were much higher than expected for the measured amount of water use (no explanation currently developed).

FUTURE PLANS: Water use, yield, rooting depth, height, leaf area, and growth stage measurements will continue to be made for as long as these rotations exist. An analysis of fallow season precipitation storage efficiency by residue type, rotation, and time of precipitation will be written for journal publication this year.

KENAF WATER USE AND PRODUCTION (FORAGE AND FIBER) UNDER A RANGE OF WATER AVAILABILITY

D.C. Nielsen

PROBLEM: Future successful and profitable agricultural production will likely be improved with increased diversity of production. Adding new crops to the traditional crops grown in this area will increase diversity. There are many unknowns associated with diversifying agricultural production with alternative crops, such as water requirements, water use-yield functions, rooting patterns, and water stress effects on plant growth, development, and yield. Kenaf is a potential alternative crop that has both fiber (paper, building materials, absorbents) and forage (livestock feed) uses.

APPROACH: Two experiments were conducted with kenaf (Everglades 41). A solid set, gradient irrigation area was planted May 11. Plots were arranged such that there would be 4 replications of 4 levels of irrigation, with the highest irrigation level being weekly replacement of evapotranspirational losses and the lowest level being rainfed with no supplemental irrigation. This experiment suffered significant stand loss from hail on June 2. In the second experiment kenaf was planted under a rainout shelter on May 8. Water treatments were 33, 67, 100, and 133% replacement of ET loss each week. Soil water measurements were made with a neutron probe. Water use was computed by the water balance method. Rainout shelter kenaf was harvested for yield and forage analysis on Aug. 3 and Sept. 29.

RESULTS: Data from the rainout shelter experiment showed a linear water use/yield response for the first cutting; the second cutting showed a linear yield response for the lowest three water application levels, but declining yield with the highest water application. Kenaf has a high water requirement, with 9.42 in. of irrigation required for the 33% water replacement treatment. This irrigation amount is just under the long-term average precipitation for the kenaf growing season in this area. With this level of water replacement, kenaf produced 6000 lb/a dry matter; with 100% replacement of water used, kenaf produced 8239 lb/a dry matter. With a full soil water profile at planting, kenaf used 5.1 in. of stored soil water from the lower 3 ft. of the 6 ft. soil profile. Soil water extraction is very similar to corn. We are awaiting the results of the forage quality analysis.

INTERPRETATION: Kenaf produces a high quality forage (as found in previous years' results), but may yield lower than corn silage and forage millet under similar water availability. The higher quality and nutritional value of kenaf will need to be considered when making an evaluation of kenaf as an alternative dryland livestock forage in this area.

FUTURE PLANS: These results will be combined with previous results and submitted for publication this year.

WATER USE, YIELD AND AGRONOMIC PRODUCTION OF ALTERNATIVE CROPS UNDER AN IRRIGATION GRADIENT

D.C. Nielsen

PROBLEM: Increased use of conservation tillage in the central Great Plains has increased precipitation storage efficiency and made more soil moisture available for crop production, thereby providing greater opportunities for more intensive crop production as compared with conventional wheat-fallow. Future successful and profitable agricultural production will likely be improved with increased diversity of production. Adding new crops to the traditional crops grown in this area will increase diversity. There are many unknowns associated with diversifying agricultural production with alternative crops, such as water requirements, water use-yield functions, rooting patterns, and water stress effects on plant growth, development, and yield.

APPROACH: Crops tested during the 1999 growing season were peas (Profi [seed] and Arvika [forage], planted Mar.31,), garbanzo beans (UC5, planted April 12), lentils (Brewer, planted April 12), cowpea (Peregrin northern brown-eye, planted June 14), pinto beans (Fisher, planted June 14), and soybean (Pioneer 9294, planted June 14). The plot area was under a solid set, gradient irrigation system. Plots were arranged such that there would be 4 replications of 4 levels of irrigation, with the highest irrigation level being weekly replacement of evapotranspirational losses and the lowest level being rainfed with no supplemental irrigation. Soil water measurements were made with a neutron probe. Water use was computed by the water balance method. Arvika forage peas were harvested on June 29. Profi peas were harvested on July 13. Lentils were harvested on July 29. Garbanzo beans were harvested on Aug. 11. Pinto beans were harvest on Sept. 11. Cowpeas were swathed on Sept. 10. Soybean forage was harvested on 22 Sep.

RESULTS: Cowpea stands heavily infested with weeds, and only a small area was maintained to provide seed increase for next year. Pea and soybean results are reported in a previous report. Pinto bean yield ranged from 1900 to 2500 lb/a over an ET range of 16 to 24 in. Lentil yield ranged from 500 to 1300 lb/a over an ET range of 12 to 17 in. Yield increases with increased water use were linear.

INTERPRETATION: Pinto bean yield in the dryland plot area (receiving only 6.6 in. rainfall during the growing season) averaged 1521 lb/a, making it a viable alternative crop if low residue and tillage/harvest concerns can be overcome. Near-normal rainfall during the lentil and garbanzo bean growing season resulted in 985 lb/a and 790 lb/a on the dryland areas of the gradient. August rainfall 3 times greater than normal resulted in 2035 lb/a of pinto beans on the dryland area.

FUTURE PLANS: Garbanzo bean, lentil, and pinto bean results will be submitted for publication. Work will continue with Profi pea, Arvika pea, soybean (forage), cowpea, and another garbanzo bean (desi type).

WINTER WHEAT-GRAIN-NITROGEN FROM LEGUME-GREEN-MANURE

M.F. Vigil, D.C. Nielsen, R.A. Bowman.

PROBLEM: With the exception of water, nitrogen (N) nutrition is the most important limiting input to profitable winter wheat production in the central Great Plains. Increases in N fertilizer costs have caused some farmers to consider alternative systems that include legumes as a source of N. Farmers need to know how these systems impact winter wheat yields, economic returns and N availability.

APPROACH: Two sites have been established in which the main plots consist of legume species: Austrian winter peas, spring field pea (cv. Profi), Hairy Vetch and a no-legume-summer-fallow plot fertilized at four N rates of 0, 30, 60, and 90 lb N/ac. Within each main-plot, four sub strip plots are maintained consisting of four legume termination dates spaced two weeks apart. Soil water is measured in all legume plots and in the fallow plots at legume planting in April, at each legume-termination event, at wheat planting and at wheat harvest to determine water used by the legume and the wheat. Above ground N and total legume biomass is determined at each termination date. Soil inorganic N is measured in each plot at each termination date in the top 2 feet of soil and at wheat planting time to monitor changes in available N. Following the legume fallow phase, wheat is planted and harvested using standard BMP's for dryland winter wheat.

RESULTS: We have four years of legume biomass data, and four years of winter wheat-yield-data. Austrian Winter peas (AWP) have produced more biomass (between 1500-3000 lbs biomass/acre) and total above ground N in plant tissue (50-130lbs N/acre) than the other legumes tested. Profi pea has averaged 1000-1500 lbs of grain per acre and has had the highest grain yields. For the AWP we calculated a water-use efficiency of 335 lbs of dry matter per inch of water used on June 13, 1994. The 335 lbs of biomass, contained 11.6 lb of N. In other words, 11.6 lbs of N was fixed or taken up by the legume for each inch of water use. The legumes used 5 inches of water (in addition to that amount lost in summer fallow) to produce 2400 lbs of dry matter. That 5 inches of water use has the potential of producing 25-30 bushels of wheat. We measured reductions in wheat grain yields all four years. Eighty-eight % of the variability in wheat yield loss could be described by a equation based on the previous year's legume water use (ET). Legume green fallow increases wheat-grain-N contents similar to fertilized summer fallow. However, the increase does not increase wheat yield and or cause a large increase in grain-N-uptake when compared to traditional summer fallow. We measured the contribution of N from legume-green-fallow to total grain-N-uptake to be as great as 12 Lbs/acre (not really very much). Soil nitrate-N measured in late March, in the growing wheat is greater after legume green-fallow than in unfertilized summer fallow. At current fertilizer costs, legume-N is too expensive to be considered a reasonable alternative to chemical-fertilizer in this system.

FUTURE PLANS: We are continuing the experiment for one more season. We believe that 3 complete cycles of the system are needed to make a fair evaluation of potential changes in soil organic matter and mineralizable N. Three publications have resulted from the study.

NITROGEN MINERALIZATION FROM MANURES AND MUNICIPAL SEWAGE SLUDGE

M.F. Vigil, B. Jacobowski, J. Davis, B. Eghbal, R.A. Bowman

PROBLEM: The disposal of animal waste and municipal sewage sludge from large population centers and concentrated animal feeding units is an environmental concern. These materials, loaded with organic and inorganic nutrients, can be recycled in crop production systems as fertilizer and soil quality amendments. If managed properly, they become a resource instead of waste. However, the quantification of suitable rates of application, methods of application, crop response, and changes in soils after repeated application are data needed to adequately develop best management practices (BMP's) for these amendments.

APPROACH: The objectives of these experiments are to determine: the amount and rate of decomposition of organic amendments (manures and sewage sludge) in farm soils, as fertilizer and as soil quality amendments for crop production. The field in-situ/ion-resin core method is being used to estimate field N mineralization (N_{min}) of 5 different manures in a Weld silt loam. Lab studies are being conducted on 20 select animal manures representing 7 animal species. N_{min} and C_{min} are being measured in manure amended Central Great Plains soils to develop first-order-decay-rate constants for these materials. Simultaneously we are evaluating computer models for their ability to predict how these amendments will impact soil nutrient availability and crop uptake. Field studies with the resin-bag in-situ N_{min} method will begin May of 1999.

RESULTS: We have analyzed the measured N_{min} at three weeks after application for the in-situ field N_{min} study. As much as 14 % of the total N applied in Hog manure was recovered 3 weeks after application using the resin-core method, and only 3.3% for beef manure. In lab studies rates of N_{min} for 20 animal manures ranged from net immobilization (0 N_{min}) to 70% of the applied N being released after 132 days of incubation at optimum temperature and near optimal soil water contents.

We estimate from our lab studies that dry-granulated sewage sludge (5.3% N) applied at rates of 1.5 ton and 9 ton per acre will release 45 and 270 lbs of N in a given season under irrigated conditions in our region (about 28% of the total N applied). Under dryland conditions we may only see 34 to 200 lbs of N released for 1.5 and 9 tons of dry sludge. Less sludge N_{min} is expected on dryland because dryland soils are less biologically active than moist irrigated soils.

FUTURE PLANS: Lab studies are mostly complete and data is being analyzed. The in-situ N_{min} field studies are in the first year of research only and will be continued. We hope to finalize the lab studies by end of summer 2000. The in-situ N_{min} study will be finalized by December 2000.

SIXTEEN YEARS OF DRYLAND CROPPING WITHOUT SUMMER FALLOW

M.F. Vigil, R.A. Bowman

PROBLEM: Conservation tillage has increased annual soil water storage. This has enabled the use of annual cropping for some soils of the central Great Plains. Annual cropping entails greater biomass production which increases surface crop residues impacting soil quality and soil water storage efficiency. This study is designed to evaluate long term changes in soil C and N under annually cropped dryland conditions under different N fertility. Short term, the study allows for the estimation of N use efficiency and fertilizer N requirements of various dryland crops.

APPROACH: This is the 16th year of the experiment, where under dryland conditions, the site has been cropped successfully with no fallow on a Weld silt loam. The site was a barley-corn rotation until 1992 when oats for hay replaced spring barley. We have had two failures in the 16 years of cropping: winter wheat was grown in 1988 to replace a hailed out corn crop in 1987 and in 1990, poor stand and aphids limited barley yields to 21 bu/acre. The experiment is a 4-rep randomized complete block where the only treatment is N fertilizer rates of 0, 20, 40, 60, 80 or 120 lbN/acre. The study is managed with no-till to conserve water and weed control has been through the use of contact and residual herbicides. Phosphorous (P) nutrition has not been limiting but low rates of P have been applied with the seed at planting or as broadcast treatments. Soil profile water and nitrates are monitored annually to determine N balance and water use efficiency.

RESULTS: Through the years, the optimum N rate for the grain crops has been between 40 and 60 lbs N/acre for wheat and between 60 and 80 lbs for corn. A buildup of excess nitrate-N can be found in the soil of plots fertilized at 80 lbs or more. These results suggest that with this soil (under dryland conditions) annual fertilizer N rates greater than 80lb/acre, are excessive for the crops and management currently available.

Triticale yields in 1995 were 5.5 ton/acre at an optimal N rate of 80 lb/acre. In 1996, maximum corn grain yields of 90 bu/acre were measured at the 120 lb N rate. At the 80 lb N rate 75 bu/acre of grain was harvested. In 1997, the unfertilized proli-pea crop got off to a slow start with a dryer than normal April. However, on 11, July 1997 we harvested 900 to 1100 lbs of grain with a whole plot average of 1011 lbs/acre. The 1998 crop of winter wheat averaged 26 bushels in the fertilized plots and 22 bushels in unfertilized plots. Corn yields in 1999 were as high as 140 bushels per acre at the 80 and 100 lb N rates. Warm season grasses (sandbur) are becoming a nuisance. This year we will plant roundup ready soybeans to help eliminate the sandbur problem followed by dormant seeded winter wheat.

FUTURE PLANS: The crops for the next three years will be roundup ready soybeans, then dormant seeded winter wheat, dry edible beans or millet. The experiment will continue for another 4 years to evaluate long term soil changes under high N management and to determine changes in soil C and N with high productivity. We are using ¹⁵N in some of the plots to evaluate fertilizer N recovery.

NITROGEN, MICRONUTRIENT, AND ROW SPACING RESPONSE OF SUNFLOWERS IN A DRYLAND ROTATION

M.F. Vigil, J.G. Benjamin, J. Schepers, R.A. Bowman, D.C. Nielsen,

PROBLEM: The current worldwide demand for edible oils has improved the profitability of sunflowers in the Central Great Plains. However, knowledge of sunflower response and fertilizer recovery of N and micronutrients in the region is limited. The objectives of these studies are: (i) to measure N and micronutrient response under no-till managed summer fallow, (ii) to determine N fertilizer recovery of this crop in a wheat-millet-sunflower-fallow rotation as affected by placement and, (iii) to compare narrow row (20") production with conventional row spacing.

APPROACH: Sunflower were planted and fertilized in a randomized split-plot 4-rep experiment. Main plots consist of rotation crop/phase (sunflowers, proso-millet, wheat or fallow) and sub-plots are fertilizer N rates of 0, 30, 60, or 90 lbN/acre. A second split was made in all plots where in the sunflowers were planted in either 20 or 30 inch rows. A seeding rate of 16,600 seeds per acre was used for both row spacings. In the 30 inch row plots, 2 rows were sprayed at the 5th leaf stage and at the early-bud stage with zinc, copper, manganese and boron. All phases of the rotation appear every year in each replication. Soil water and inorganic N are monitored at planting and after harvest to assess water and N use efficiency and to evaluate deep N and water extraction by sunflowers. Individual plots are 60 ft by 240 ft in size. Surface and deep placed ¹⁵N labeled N is being used to evaluate fertilizer N recovery with soil depth and fertilizer recovery with N placement.

RESULTS: With nearly 6 inches of rainfall on these plots in August, we measured a significant yield response to added N fertilizer (see table). Yields were also significantly greater when planted in 20 inch rows as compared to 30 inch rows. Micronutrients did not significantly increase or decrease sunflower yields. We measured 21% recovery of fertilizer at the 4 foot depth and 60% recovery from banded N placed 4 inch deep 4 inch away from the row. We were surprised that as much as 50% recovery was measured from fertilizer N placed at the 2 foot depth.

	Row spacing		
N rate	30 inch rows	20 inch no micronutrients	20 inch with micronutrients
lbs/acre	----- Grain yields (lbs/acre) -----		
0	1538	1776	1963
30	2072	2417	2594
60	2090	2682	2556
90	2224	2505	2866

FUTURE PLANS: For these studies two years of complete data has not been collected. The N response of sunflowers in a rotation requires at least 2 complete cycles of the rotation for long term conclusions. The row spacing work will be continued for another year. Micronutrients will be evaluated one more year as well. The ¹⁵N placement work is nearing completion.

SOIL CARBON AND NITROGEN CHANGES IN A LONG TERM TILLAGE STUDY

M.F. Vigil, R.A. Bowman, R.L. Anderson

PROBLEM: Winter wheat-fallow is the dominant cropping system in the Central Great Plains region of the United States. During fallow, weeds are generally controlled using sweep-plow tillage (stubble mulch). Weed control with herbicides is generally too expensive unless a more intensive rotation is adopted. On the other hand, conventional tillage during fallow reduces soil organic matter levels at the soil surface and increases wind and water erosion.

APPROACH: This study was originally established in 1967 by Darryl Smika, and modified by Merle Vigil and Randy Anderson in 1996. In 1967 four weed control strategies during fallow were compared. These were no-till (residual and contact herbicides only), reduce-till (residual herbicides in August after wheat harvest followed by tillage the next summer after residual herbicides had failed), stubble-mulch (sweep-plow managed summer fallow), and a moldboard plow treatment. This core set of plots has been kept since 1967. We have added a four year rotation of wheat-proso millet (or corn depending on weed and moisture conditions)-sunflower-summer fallow. This rotation was established to evaluate long term changes in soil Carbon and soil organic matter as influenced by intensive management. Other studies of an academic nature have included: a Delta ^{13}C dating of soil organic matter pools, studies to evaluate infiltration and compaction as influenced by long term tillage, and studies to evaluate fungal versus bacterial activity as influenced by tillage.

RESULTS: In general the no-till plots have not produced better than the tilled plots. The moldboard plow plots are less weedy than either the sweep tilled plots and/or the no-till or reduce-till plots. The plots that have been exclusively in a wheat-fallow rotation are infested with jointed goat grass and cheat grass. Plots that have had a three year rotation of wheat-corn-fallow are relatively much cleaner with respect to weeds. Soil organic matter levels are being evaluated as a function of tillage and soil depth. The largest difference (as you might expect) is with lower surface organic matter levels in the moldboard plow treatment as compared with the no-till plots. Nearly 15 times more fungal activity is measured in the surface 15 cm of these soils than bacterial activity with no significant differences between tilled and no-till plots.

FUTURE PLANS: Grassy weed pressure is so intense that we will not grow winter wheat on the land for the next 4 years. Oats or peas will be substituted for winter wheat over the next few years until we get control of the cheat and jointed goat grass problems. Because of its long term history the experiment has become valuable for looking at long term changes in soil organic matter, total soil N and C and changes in soil tilth at the soil surface. The experiment has been identified as a unique part of a network of long term experimental sites across the United States and Canada. Long term changes in soil surface C and soil tilth is being evaluated across that site network. We would like to keep the experiment going for 8 years in order to complete 2 cycles of the four year rotation.

PUBLICATIONS

- Aiken, R.M., D.C. Nielsen, M.F. Vigil, and L.R. Ahuja. 1999. Field evaluation of energy balance simulation of surface soil temperatures. Proc. Wind Erosion: An International Symposium/Workshop, USDA-ARS, Manhattan, KS.
- Anderson, R.L., R.A. Bowman, D.C. Nielsen, M.F. Vigil, R.M. Aiken, and J.G. Benjamin. 1999. Alternative crop rotations for the central Great Plains. J. Prod. Agric. 12:95-99.
- Anderson, R.L. 1999. Cultural strategies reduce weed densities in summer annual crops. Weed Technol. 13:314-319.
- Anderson, R.L. 1999. Improving weed control in corn and sunflowers with narrow rows. p. 88-97. In Proceedings, 11th Annual Meeting, Colorado Conservation Tillage Association. Sterling, CO. 193 pp.
- Anderson, R.L. 1999. Guidelines for application of postemergence herbicides to control grasses in corn. p. 75-78, in Proceedings, 11th Annual Meeting, Colorado Conservation Tillage Association. Sterling, CO. 193 pp.
- Anderson, R. L. 1999. Principles for designing semiarid rotations. p. 1-24 in Proceedings, Central Great Plains Conservation Tillage Symposium. USDA-NRCS & Monsanto Co. Cheyenne, Wyo. 108 pp.
- Bowman, R.A., M.F. Vigil, D.C. Nielsen, and R.L. Anderson. 1999. Soil organic matter changes in intensively cropped dryland systems. Soil Sci. Soc. Am. J. 63:186-191.
- Bowman, R. A., and M. F. Vigil. 1999. Adsorption, movement, and transformations of manure-P and organic P in soils. Agron. Abstr. p. 206. Am. Soc. Agron. National meeting, Salt lake City, UT.
- Jasieniuk, M., B. Maxwell, R. Anderson, J. Evans, D. Lyon, S. Miller, D. Morishita, A. Ogg, S. Seefeldt, P. Stahlman, F. Northam, P. Westra, Z. Kebede, and G. Wicks. 1999. Development of a bioeconomic model for management of *A. cylindrica* in *T. aestivum*: 1. Site-to-site and year-to-year variation in *T. aestivum* yield loss equations. Weed Sci. 47:529-537.
- Kaan, Dennis A. 1999. Risk and resilience in agriculture.
- Kaan, Dennis A. 1999. Crop enterprise cost estimates for 1998 in Northeastern Colorado. 1999 Golden Plains Area Agricultural Handbook. 14 pp.
- Kaan, Dennis A. 1999. Livestock enterprise budgets. 1999 Golden Plains Area Agricultural Handbook. 15 pp.
- Kaan, Dennis A., Daniel O'Brien. 1998. Sunflower cost-return prospects. High Plains Sunflower Production Handbook.

Kaan, Dennis A. 1998. Crop enterprise cost estimates for 1997 in Northeastern Colorado. 1998 Golden Plains Area Agricultural Handbook. 14 pp.

Kaan, Dennis A. 1998. Livestock enterprise budgets. 1998 Golden Plains Area Agricultural Handbook. 15 pp.

Kaan, Dennis A. 1998. Oilseeds and dry bean outlook. The Science, Ethics and Economics of Biotechnology in Agriculture. Governor's Colorado Agricultural Outlook Forum proceedings.
Kaan, Dennis A. 1996. Understanding your financial situation. Managing for Today's Cattle Market and Beyond. 5 pp.

Kaan, Dennis A., J.P. Hewlett. 1994. Western integrated ranch/farm education financial management. 212 pp.

Laymond R.E., and M.F. Vigil. 1999. Nutrient management. p. 4-5. *In* R. Meyer, Dana Belshe and Rebecca Darling (ed.) High Plains sunflower production handbook. Kansas State University Ag. Exp Sta. MF-2384.

Lyon D., H.D. Sunderman, M.F. Vigil and D.C. Nielsen. 1999. Crop rotations and residue management. p. 28-30. *In* R. Meyer, Dana Belshe and Rebecca Darling (ed.) High Plains sunflower production handbook. Kansas State University Ag. Exp Sta. MF-2384.

Munson C.L., J.C. Whittier, D.N. Schutz, and R.L. Anderson. 1999. Reducing annual cow cost by grazing windrowed millet. Professional Animal Scientist 15:40-45.

Nielsen, D.C., R.L. Anderson, R.A. Bowman, R.M. Aiken, M.F. Vigil, and J.G. Benjamin. 1999. Winter wheat and proso millet yield reduction due to sunflower in rotation. J. Prod. Agric. 12:193-197.

Nielsen, D.C. 1999. Sunflower water use relationships. The Sunflower 25:8-9.

Nielsen, D.C. 1999. Water requirements and potential impacts on following crops. *In* R. Meyer, D. Belshe, D. O'Brien, and R. Darling (ed.) High Plains Sunflower Production Handbook. Kansas State University. Ag. Exp. Stn. MF-2384. Manhattan.

Pester, T., P. Westra, R. Anderson, P. Stahlman, G. Wicks, D. Lyon, and S. Miller. 1999. Integrated management systems for jointed goatgrass in the Central Great Plains. *In* Proceedings, 1999 Jointed Goatgrass Symposium. Western Society of Weed Science. 52:159-164. Colorado Springs, CO.

Pikul J.L Jr., L. Carpenter Boggs, M.F. Vigil and W.E. Riedell. 1999. Nitrogen and water use in Corn soybean rotation under ridge and conventional tillage. Agron. Abstr. Pp. 278. Am. Soc. Agron. National meeting, Salt Lake City, UT.

Skinner, R. H., J. D. Hanson and J. G. Benjamin. 1999. Nitrogen Uptake and Partitioning under Alternate- and Every-furrow Irrigation. *Plant and Soil* 210:11-20.

Tanaka, D.L. and R.L. Anderson. 1999. Cultural system guidelines for weed control in sunflowers. p. 1-8, *in* Proceedings, 21th National Sunflower Association Research Workshop, Fargo, ND.

Tanaka, D.L. and R.L. Anderson. 1999. Sunflower row spacing and plant population. p. 117-121, *in* Proceedings, Manitoba-North Dakota Zero-Till Conference. Minot ND.

Vigil, M.F., and D.C. Nielsen. 1999. Are legumes logical? *Colorado Farmer-Stockman* 53:27-30. (popular publication).

Vigil M.F. 1999. Reactions of fertilizer N in soils. p.46-56. *In* Proceedings central Great Plains conservation tillage symposium. USDA-NRCS & Monsanto Co. Cheyenne Wyo. 108 pp.

Vigil M.F. 1999. Legumes revisited. p. 110-124. *In* Proceedings, 11th Annual meeting , Colorado Conservation tillage association. Sterling CO. 193 pp.

Vigil M.F. 1999. Proceedings of the 11th Annual meeting, Colorado conservation tillage association. Contributing Editor. 193 pp.

Vigil M.F. 1998. Proceedings of the 10th Annual meeting, Colorado conservation tillage association. Contributing Editor. 45 pp.

Vigil M.F., D.C. Nielsen, and R.A. Bowman. 1999. Nitrogen dynamics in winter wheat-legume fallow. *Agron. Abstr.* Pp. 257. Am. Soc. Agron. National meeting, Salt Lake City, UT.

ACCEPTED

Anderson R.L. 2000. Ecology and interference of proso millet in semiarid corn. *Weed Technol.*

Anderson, R.L. 2000. Cultural strategies for winter wheat production in continuous cropping. *In* Proceedings, 12th Annual Meeting, Colorado Conservation Tillage Association. Sterling, CO.

Anderson, R.L. 2000. Managing yield variability in corn with cultural practices. *In* Proceedings, 12th Annual Meeting, Colorado Conservation Tillage Association. Sterling, CO.

Anderson, R.L. 2000. Synergism--Some Crops Improve Yields of Following Crops. *In* Proceedings, Dryland Corn Production Workshop, University of Nebraska Extension Service. Sidney and Alliance NE.

Bowman, R. A., Oswald Eppers, and Eduardo Panique. 1999. Pruebas de laboratorio, analisis de plantas, y tecnicas de diagnosticas. *Proceedings: First National Soil Science Congress of Bolivia* La Paz, Bolivia.

Bowman, R.A. 1999. Follow-up to Soils laboratory Improvement - Instituto Boliviano de Tecnologia Agropecuaria (IBYA), and Report on National Soil Congress. Final Report to IBTA, Tarija, Bolivia. 8 pages. Submitted through Agricultural Cooperative Development, International/Volunteers in Overseas Cooperative Assistance (ACDI/VOCA).

Bowman, R.A. 1999. Soils Laboratory Improvement - Oruro Laboratory. Final Report to Spectrolab in Oruro, Bolivia. Submitted through Agricultural Cooperative Development, International/Volunteers in Overseas Cooperative Assistance (ACDI/VOCA).

Bowman, R. A., and M. F. Vigil. 1999. Sulfur and micronutrient changes as a function of dryland cropping intensity. Proc. Great Plains Fertility Conference. Denver, CO.

Bowman, R. A., and M. F. Vigil. 1999. Phosphorus: What happens in the Soil? *In* Proceedings Colo. Conservation Tillage Assoc. Sterling CO.

Jacobowski B.R., M.F. Vigil, J.G. Davis, and B. Eghbal. 1999. In situ nitrogen mineralization of manure amended soil. *In* Proceedings Great Plains Soil Fertility Conference. Vol 8.

McMaster, G.S., R.M. Aiken, and D.C. Nielsen. 2000. Optimizing wheat harvest cutting height for harvest efficiency and soil and water conservation. *Agron. J.* 92:XXX-XXX. (accepted 15 Aug 1999).

Pikul J.L Jr., L. Carpenter Boggs, M.F. Vigil and W.E. Riedell. 1999. Corn soybean yields and soil condition under ridge and chisel plow tillage in the northern corn belt. *In* Proceedings Great Plains Soil Fertility Conference. Vol 8.

Wright, S.F. and R.L. Anderson. 2000. Aggregate stability and glomalin in alternative crop rotations for the central Great Plains. *Biology & Fertility of Soils*.

IN PREPARATION

Bowman, R. A., D. C. Nielsen, M. F. Vigil, and R. M. Aiken. 2000. Does sunflower in rotation reduce surface crop residue protection, soil quality, and subsequent winter wheat yields? Submitted to *Soil Sci*.

Bowman, R. A., and R. L. Anderson. 2000. Comparison of soil organic matter pools in adjacent wheat-fallow, CRP, and native grassland of eastern Colorado. To be submitted to *J. Soil Water Conserv*.

Bowman, R., and M. F. Vigil. 2000. Adsorption, movement, and transformations of manure P and organic P in soils. To be submitted to *Soil Sci. Journal*.

Bowman, R. A., J. D. Reeder, and G. E. Schuman. 2000. Comparison of P pools in native, cultivated, and CRP lands. To be submitted to *Soil Sci*.

- Carpenter-Boggs, Lynne, J.L. Pikul Jr., M.F. Vigil and W.E. Riedell. 2000. Soil nitrogen mineralization influenced by crop rotation and N fertilization rate.
- Derksen, D., R. Anderson, R. Blackshaw, and B. Maxwell. 2000. Weed dynamics and management strategies for cropping systems in the Northern Great Plains. *Agron. J.*
- Jasieniuk, M., B. Maxwell, R. Anderson, J. Evans, D. Lyon, S. Miller, D. Morishita, A. Ogg, S. Seefeldt, P. Stahlman, P. Westra, and G. Wicks. 2000. Development of a bioeconomic model for management of *A. cylindrica* in *T. aestivum*: II. Evaluation of models predicting crop yield response to weed and crop density. *Weed Sci.*
- Ma, L., D.C. Nielsen, L.R. Ahuja, K.W. Rojas, J.D. Hanson, and J.G. Benjamin. 2000. Modeling corn responses to water stress under a gradient irrigation system. (submitted to *Agron. J.*).
- Nielsen, D.C., L. Ma, and L.R. Ahuja. 2000. Simulating soybean water stress effects with the Root Zone Water Quality Model. (in preparation for *Trans. ASAE*).
- Nielsen, D.C. 2000. Forage characteristics of kenaf grown under an irrigation gradient. (in preparation for *Crop Sci.*).
- Nielsen, D.C. 2000. Water use/yield relationships for dry bean, pea, chickpea, and lentil. (in preparation for *Agron. J.*).
- Pester, T., P. Westra, R.L. Anderson, D. Lyon, S. Miller, P. Stahlman, and G. Wicks. *Secale cereale* interference and economic thresholds in *Triticum aestivum*. *Weed Sci.*
- Shaffer M. M.F. Vigil, and R.L. Anderson. 2000. Simulating crop residue decay on the soil surface testing and validation.
- Tanaka, D.L. and R.L. Anderson. An integrated approach to weed control in sunflowers. *In* Proceedings, 22th National Sunflower Association Research Workshop, Fargo, ND.
- Vigil M.F., D.C. Nielsen, and R.A. Bowman. 2000. Assessment of the nitrogen contribution of annual legumes to winter wheat in a legume-green fallow rotation.
- Vigil M.F., and R.L. Anderson. 2000. Wheat and sunflower residue loss as affected by reduce-till and no-till summer fallow.

